

FINAL REPORT
APRIL 1997

REPORT NO. 91-03-1

ENVIRONMENTAL MONITORING
OF RAPID DEPLOYMENT
AMMUNITION
AT FORT BRAGG, NC

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SAVANNA, ILLINOIS 61074-9639

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<p>The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the Defense Ammunition Logistics Activity (AMMOLOG) to monitor environmental conditions of ammunition items in open storage under tarpaulins at Ft. Bragg, NC. Results from monitoring indicated that the tarpaulins provided little to no protection from the effects of solar radiation with portions of the ammunition reaching temperatures of 140 degrees Fahrenheit. The tarpaulins did, however, provide sufficient protection from moisture with the humidity under the tarpaulins remaining at or below the ambient humidity.</p>					
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U.S. ARMY DEFENSE AMMUNITION CENTER
VALIDATION ENGINEERING DIVISION
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ENVIRONMENTAL MONITORING OF RAPID DEPLOYMENT AMMUNITION
AT FORT BRAGG, NC

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PART 1

INTRODUCTION

A. BACKGROUND. The U.S. Army Defense Ammunition Center (DAC), Validation Engineering Division (SIOAC-DEV), was tasked by the Defense Ammunition Logistics Activity (AMMOLOG) to monitor environmental conditions of ammunition items in open storage under tarpaulins at Ft. Bragg, NC.

B. AUTHORITY. The test was accomplished IAW mission responsibilities delegated by U.S. Army Armament Munitions and Chemical Command (AMCCOM), Rock Island, IL. Reference is made to the following:

1. Change 4, 4 October 1974, to AR740-1, 23 April 1973, Storage and Supply Activity Operation.

2. AMCCOM-R, 10-17, Mission and Major Functions of USADACS, 13 January 1986.

C. OBJECTIVE. The objective of the environmental monitoring was to assess the environment to which the ammunition was being subjected while stored outside under tarpaulins.

D. CONCLUSION. Results from the environmental monitoring indicated that the tarpaulins provided very little benefit in terms of solar heating. Temperature data collected indicated that portions of the ammunition were reaching temperatures of 140 degrees Fahrenheit. The results also indicated that the tarpaulins did a satisfactory job of shielding the ammunition from moisture. Humidity levels within the 463L pallet loads were at or below ambient humidity levels throughout the monitoring.

E. RECOMMENDATION. In order to cut down the effects from solar heating, recommend that frames be built around the pallets to suspend the tarpaulins 12 inches or more from the top and

sides of the pallets. This space will allow air to circulate around the pallets to transfer heat and possibly moisture away from the pallets.

PART 2

27 AUGUST 1991 - 28 FEBRUARY 1993

ATTENDEES

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PART 3

TEST PROCEDURES

Initially, seven 463L pallet loads of ammunition were instrumented with a Campbell Scientific, Incorporated data logger with eight temperature and humidity probes. Seven of the eight probes were placed at the approximate center of the pallets and the eighth probe was placed in a louvered sunshield to monitor the ambient environmental conditions. The data logger was programmed to take readings every hour and store them in a solid state data storage module which was switched out approximately every three months and shipped back to DAC where the readings were downloaded onto a computer for analysis. Monitoring began on 27 August 1991.

While analyzing the first group of test data returned from Ft. Bragg, internal ammunition temperatures were noted to be almost 10 degrees Fahrenheit higher than the ambient temperature. The extent of the temperature elevation at the position within the pallet raised concern as to the extent of the temperature elevation for the top portion of the pallet. On 25 November 1991, a second data logger was installed at the test setup to monitor the temperatures at the top of each pallet load of ammunition. This data logger was also programmed to take readings every hour and store them in a solid state data storage module.

Problems with inadequate battery power were incurred throughout the monitoring. The most significant resulting in the loss of approximately six weeks of data for the second data logger at the end of the monitoring cycle.

PART 4

TEST RESULTS

Analysis of the temperature and humidity readings consisted of monthly calculations for the minimum, maximum, and average values for each of the 30 channels of test data collected. Histograms were also constructed on a monthly basis for the humidity readings collected during the test. The tabular results from these calculations are listed in part 6. From these tabular results, graphs were constructed to determine the amount of temperature elevation that was occurring within the ammunition and what effect the tarpaulins were having on the humidity within the ammunition. As seen in the first set of graphs in part 6, the peak monthly readings for the top of the pallet, middle of the pallet, and ambient temperature have been plotted for each pallet for the duration of the test. Peak temperatures for the top of the pallets were in the range of 135 degrees Fahrenheit to 140 degrees Fahrenheit for the majority of the pallets with one pallet reaching 146 degrees Fahrenheit. Temperatures for the middle of the pallets were in the range of 110 degrees Fahrenheit to 120 degrees Fahrenheit for the majority of the pallets with two of the pallets showing peak temperatures for the middle of the pallet over 130 degrees Fahrenheit.

Graphs utilizing the peak monthly humidity reading were also generated in an effort to assess what effect the tarpaulins were having on the humidity within the pallet loads of ammunition. As seen in the second set of graphs in part 6, the peak monthly readings for the top of the pallet, middle of the pallet, and ambient humidity have been plotted for each pallet for the duration of the test. The graphs indicate that the humidity within the pallets was at or below the ambient humidity during the environmental monitoring period.

During the final phase of graphing, histograms were plotted for each month for the top and middle of each pallet. Occurrences were plotted based on percentages due to the fact that the

number of occurrences would be skewed against the data logger that collected more readings during a particular month. As with the peak humidity graphs, the histograms also indicate that the humidity within the pallets was at or below the ambient humidity during the environmental monitoring period.

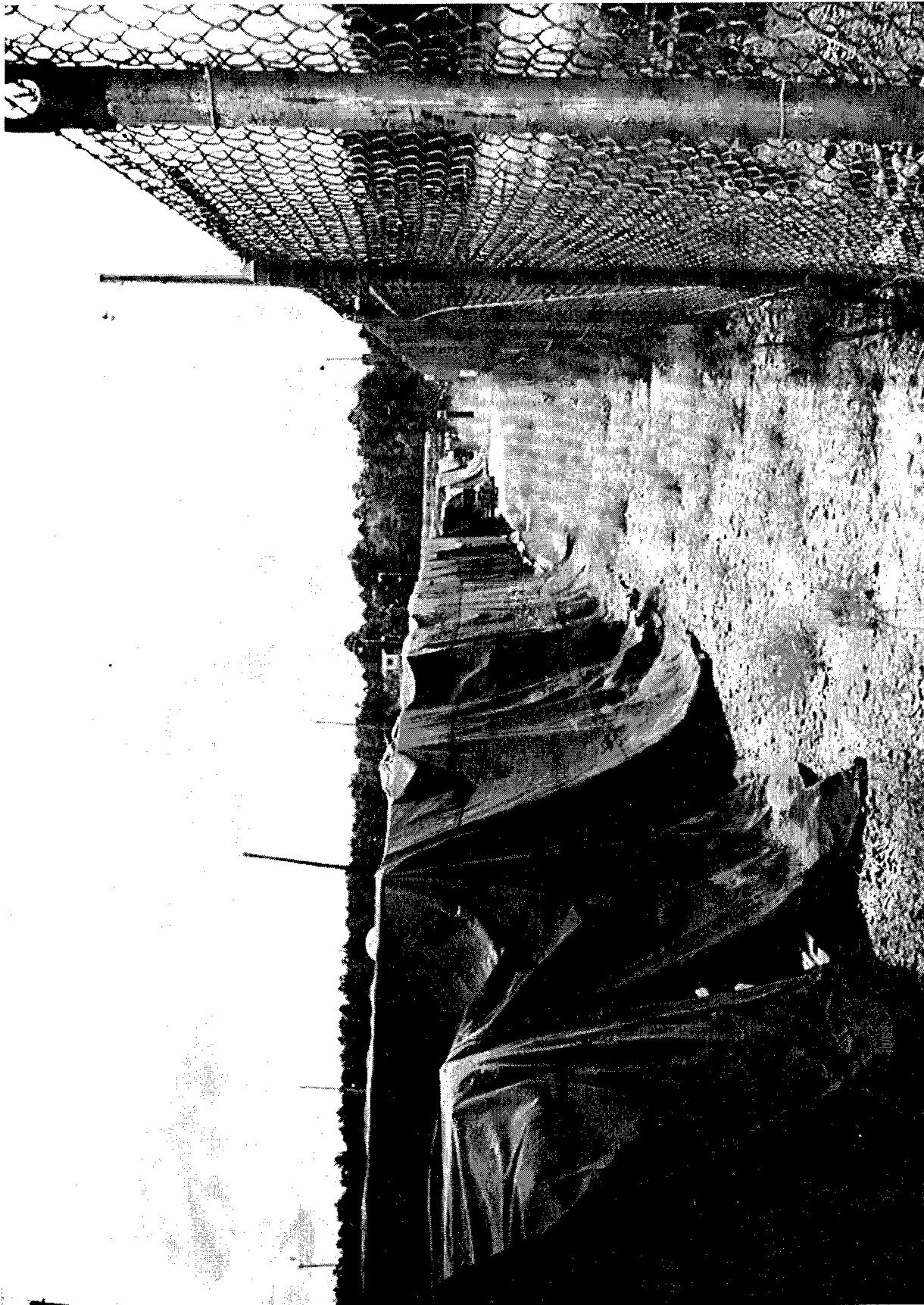
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PHOTOGRAPHS



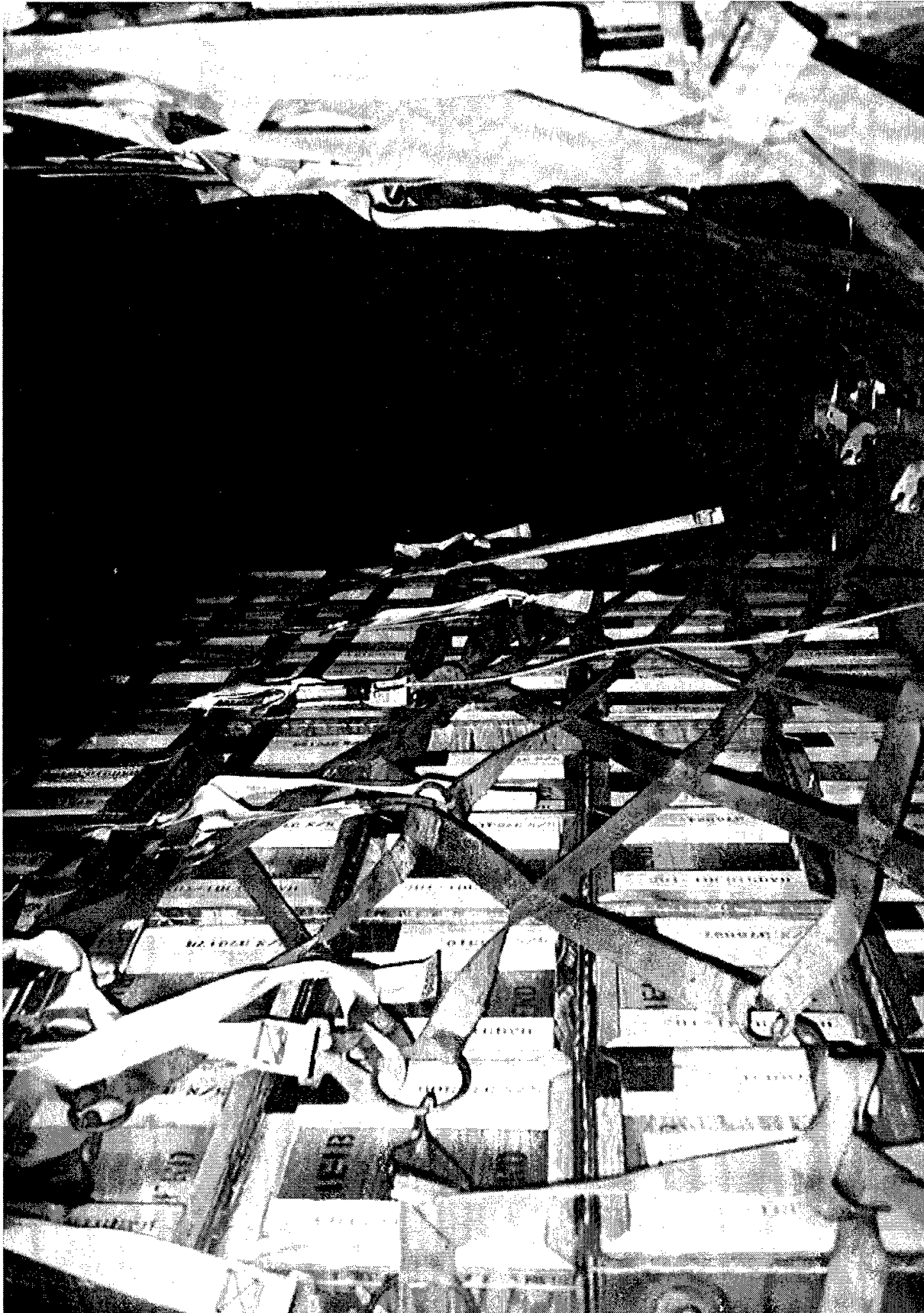
	U.S. ARMY DEFENSE AMMUNITION CENTER	
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<p>PHOTO NO. DAC-91-03-01: This photograph shows one of the Campbell Scientific data loggers that was used to collect the environmental data and the sunshield housing the probe used to collect the ambient temperature and humidity.</p>
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	PHOTO NO. DAC-91-03-02: This photograph shows the row of tarpaulin-covered pallets.	
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PHOTO NO. DAC-91-03-03: This photograph shows the ammunition loaded on the 463L pallets. Note the position at the middle of the pallet.

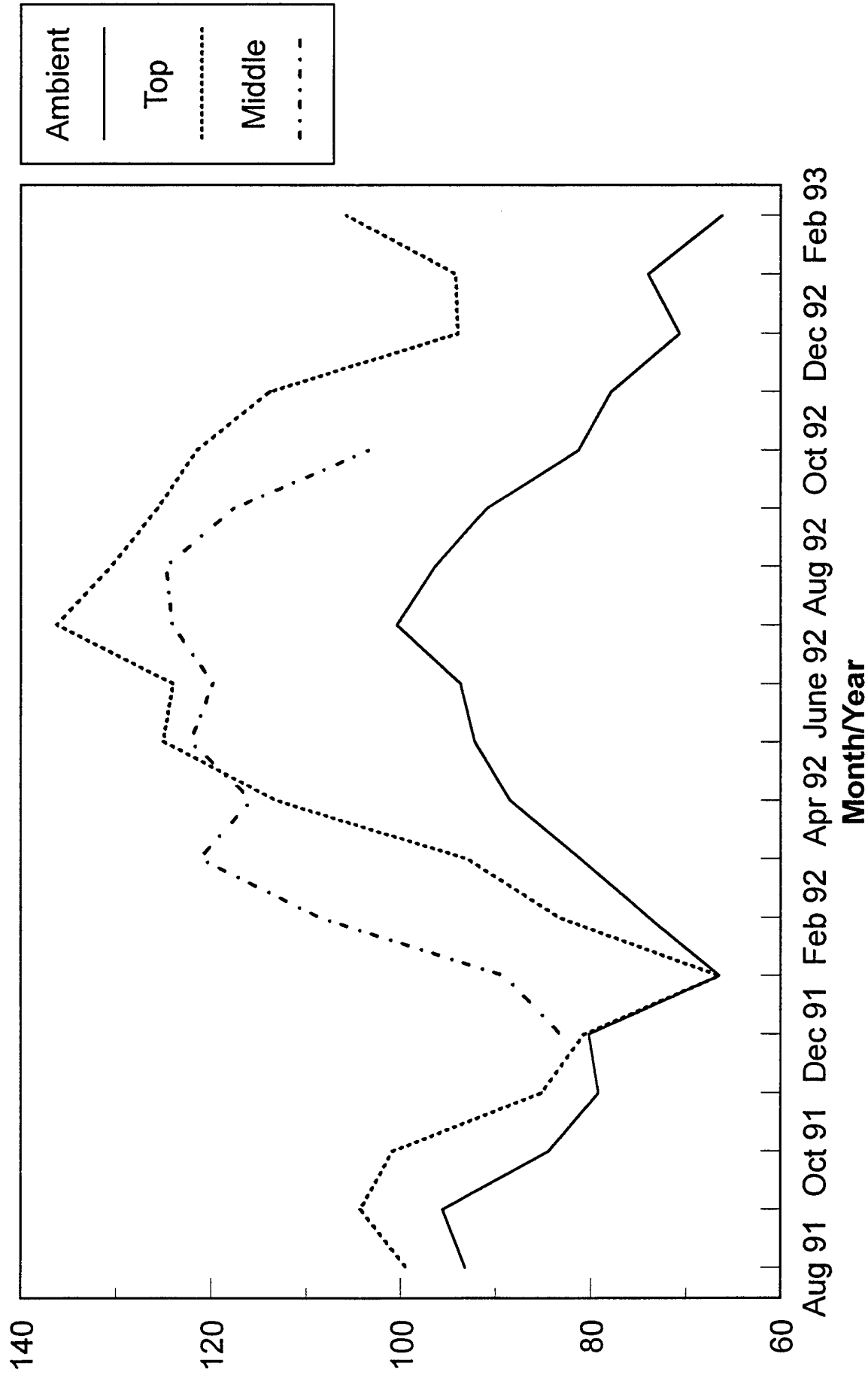
PART 6

GRAPHS

Peak Monthly Temperatures for Pallet 24

August 91 - February 93

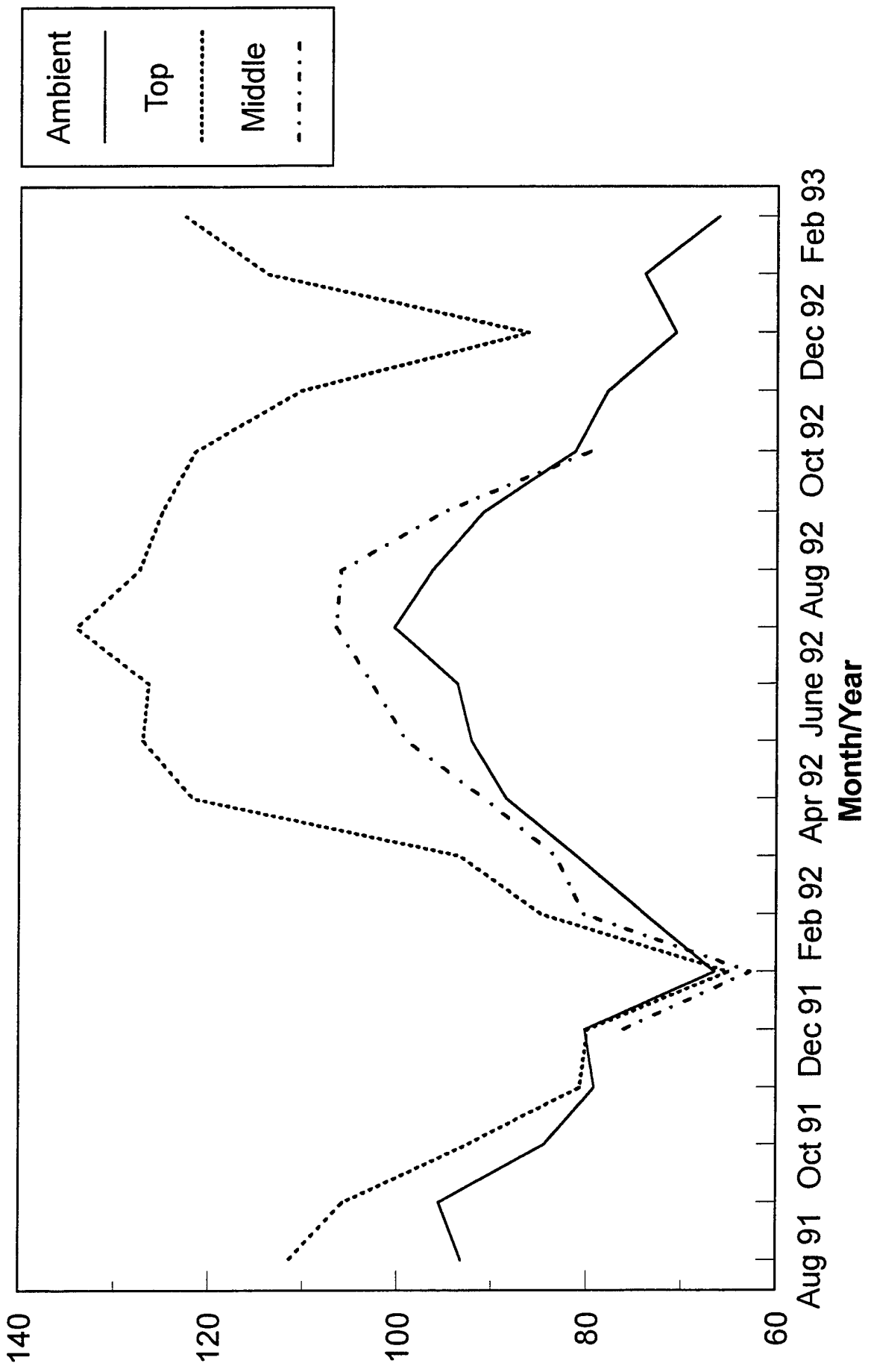
Temperature in Fahrenheit



Peak Monthly Temperatures for Pallet 23

August 91 - February 93

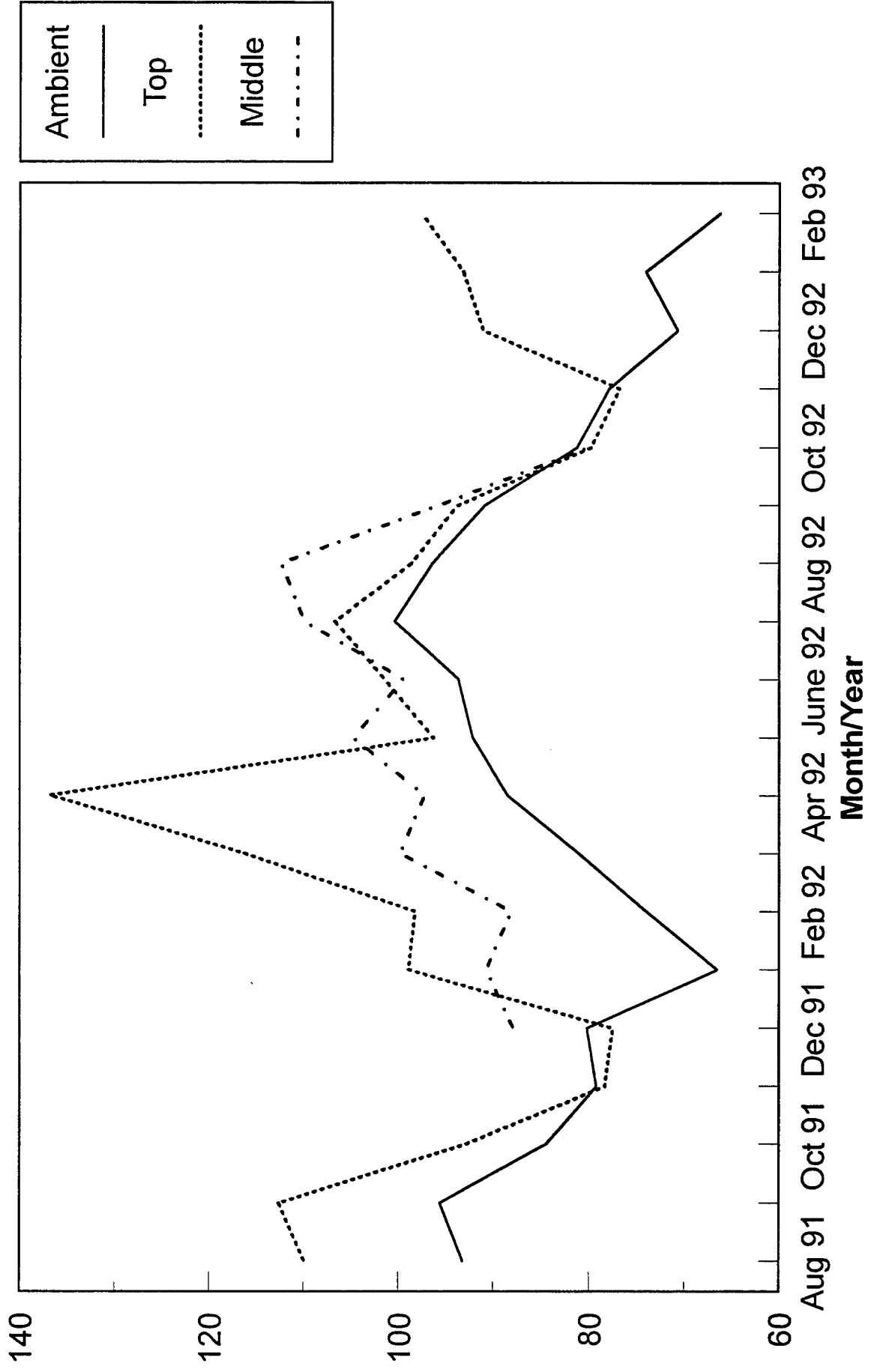
Temperature in Fahrenheit



Peak Monthly Temperatures for Pallet 28

August 91 - February 93

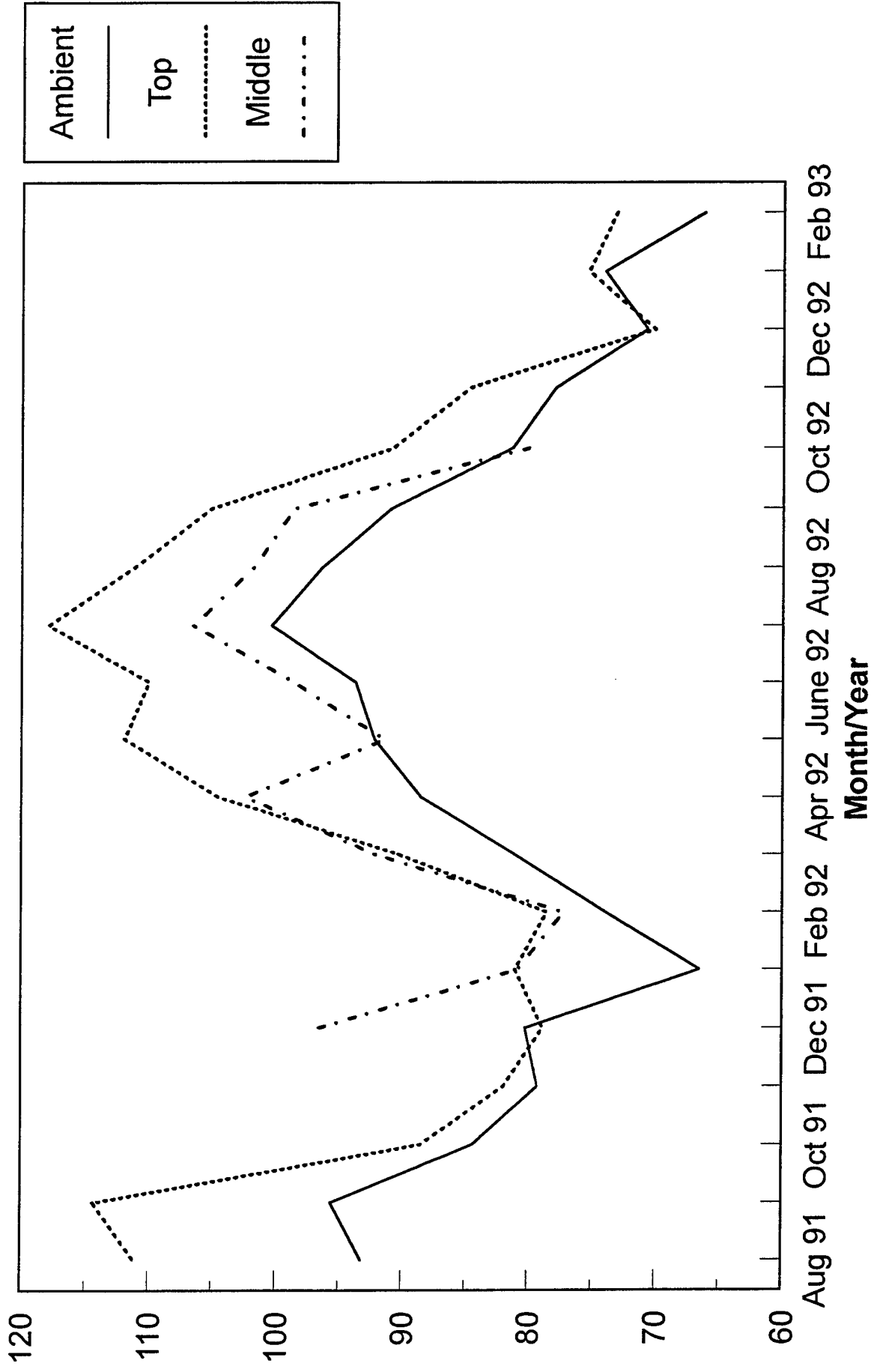
Temperature in Fahrenheit



Peak Monthly Temperatures for Pallet 2

August 91 - February 93

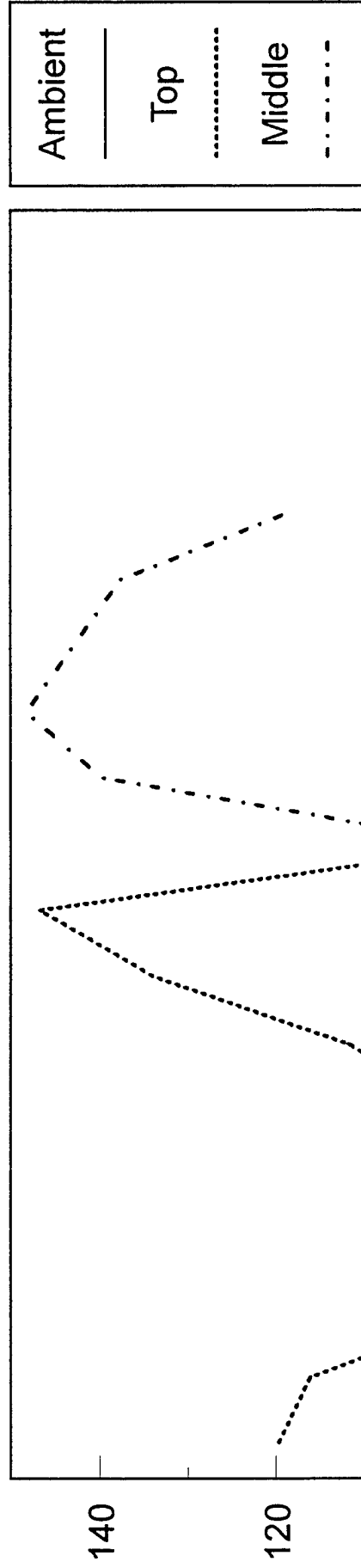
Temperature in Fahrenheit



Peak Monthly Temperatures for Pallet 4

August 91 - February 93

Temperature in Fahrenheit

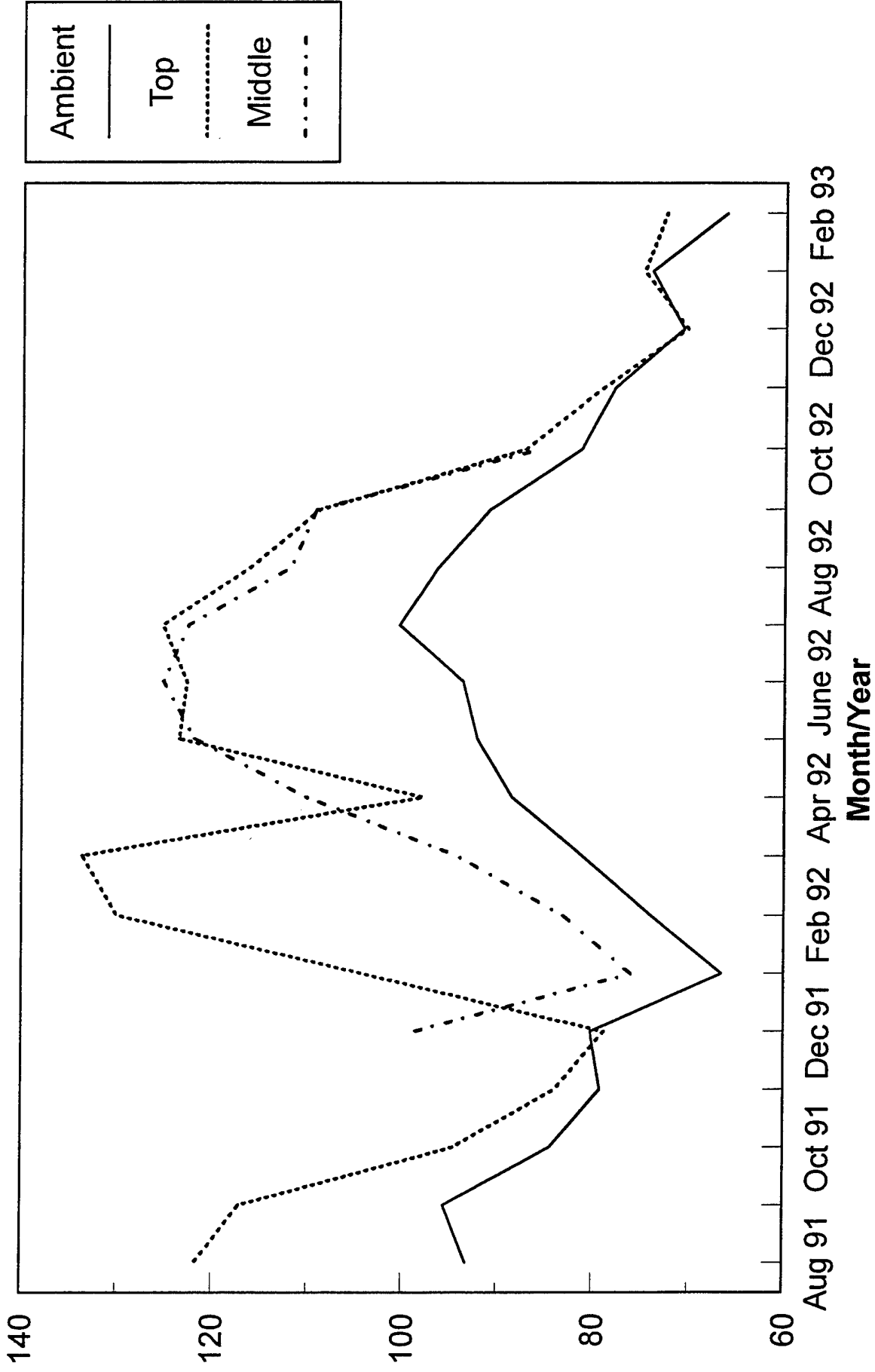


Aug 91 Oct 91 Dec 91 Feb 92 Apr 92 June 92 Aug 92 Oct 92 Dec 92 Feb 93
Month/Year

Peak Monthly Temperatures for Pallet 7

August 91 - February 93

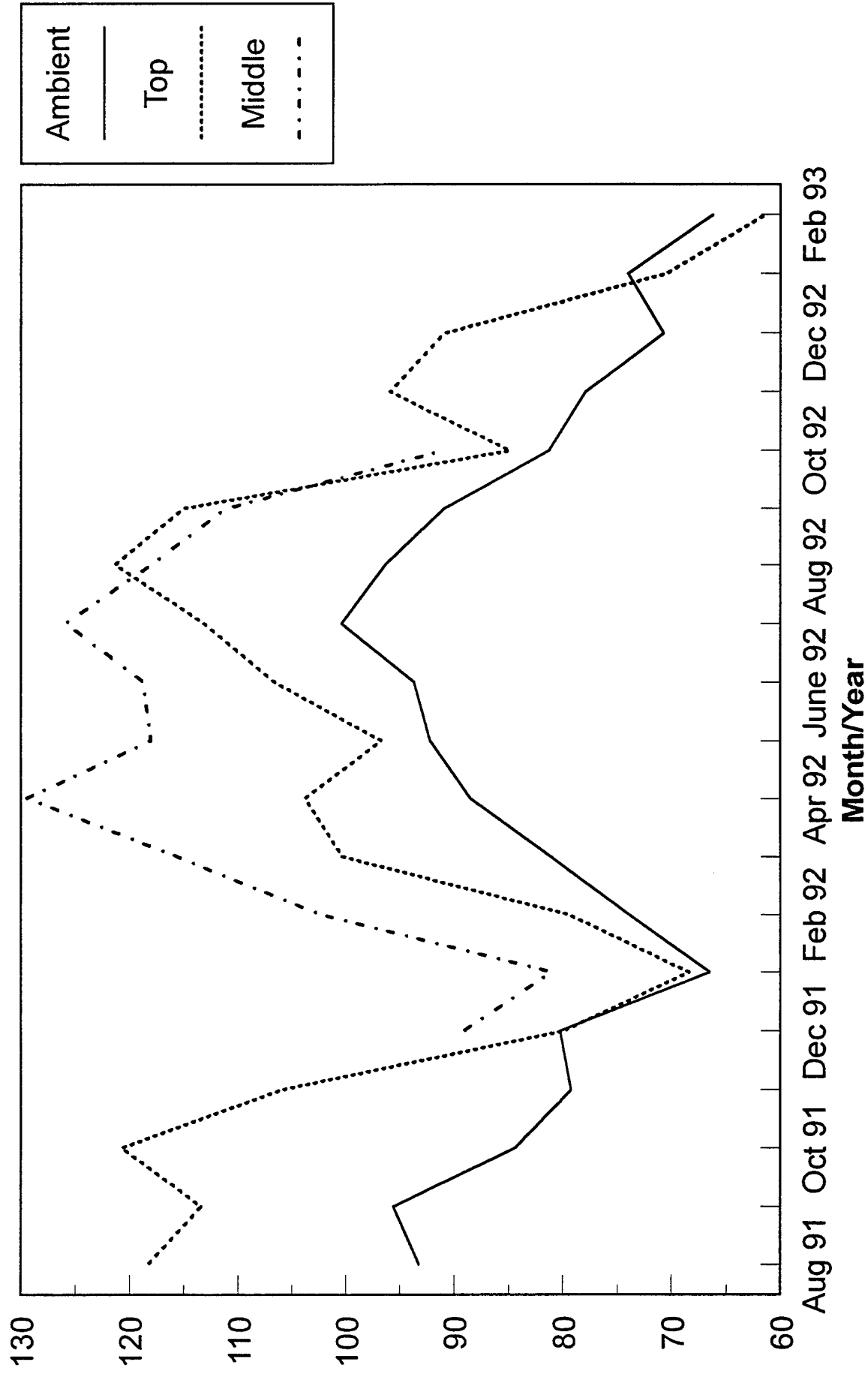
Temperature in Fahrenheit



Peak Monthly Temperatures for Pallet 9

August 91 - February 93

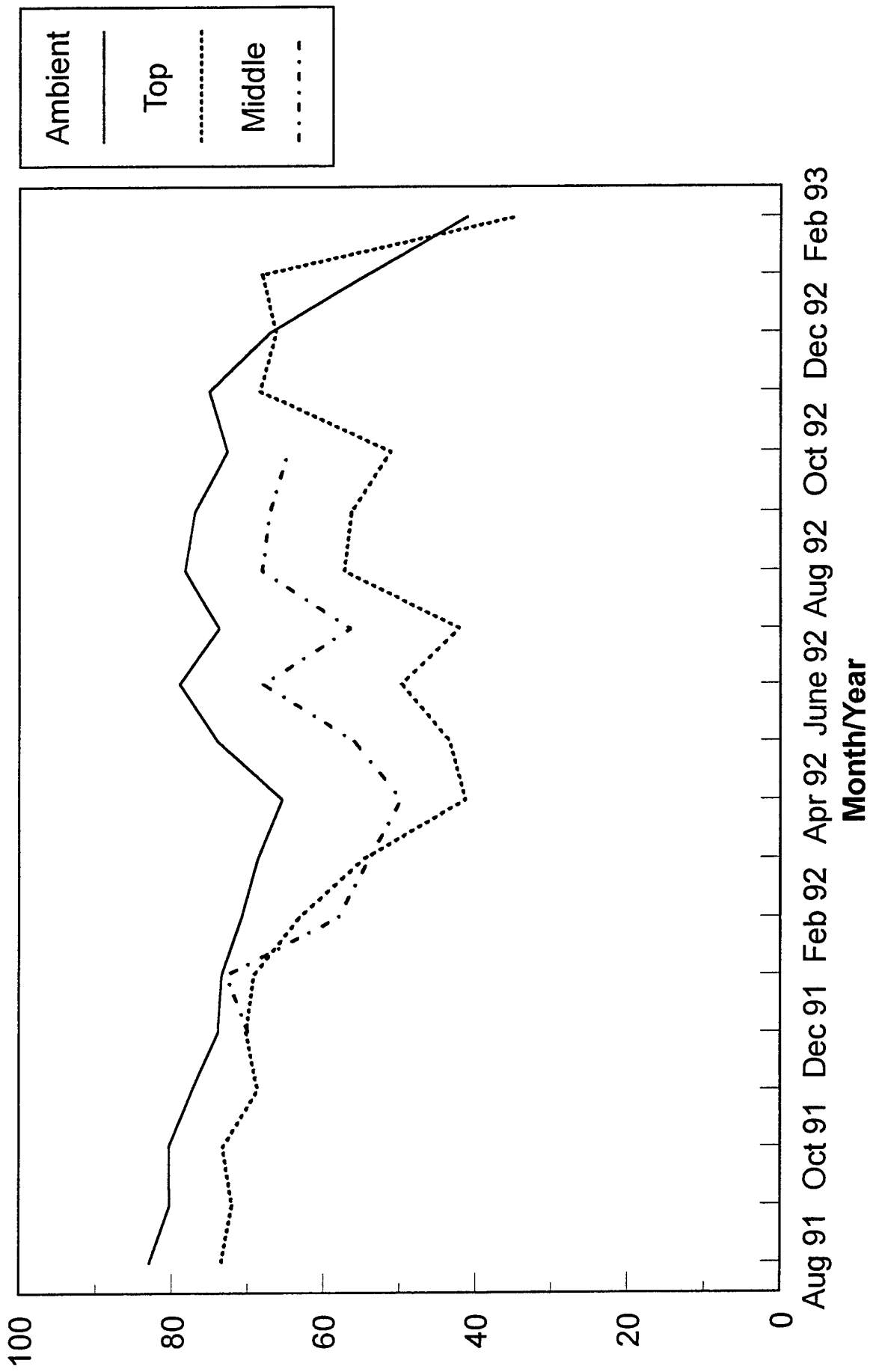
Temperature in Fahrenheit



Peak Monthly Humidity for Pallet 24

August 91 - February 93

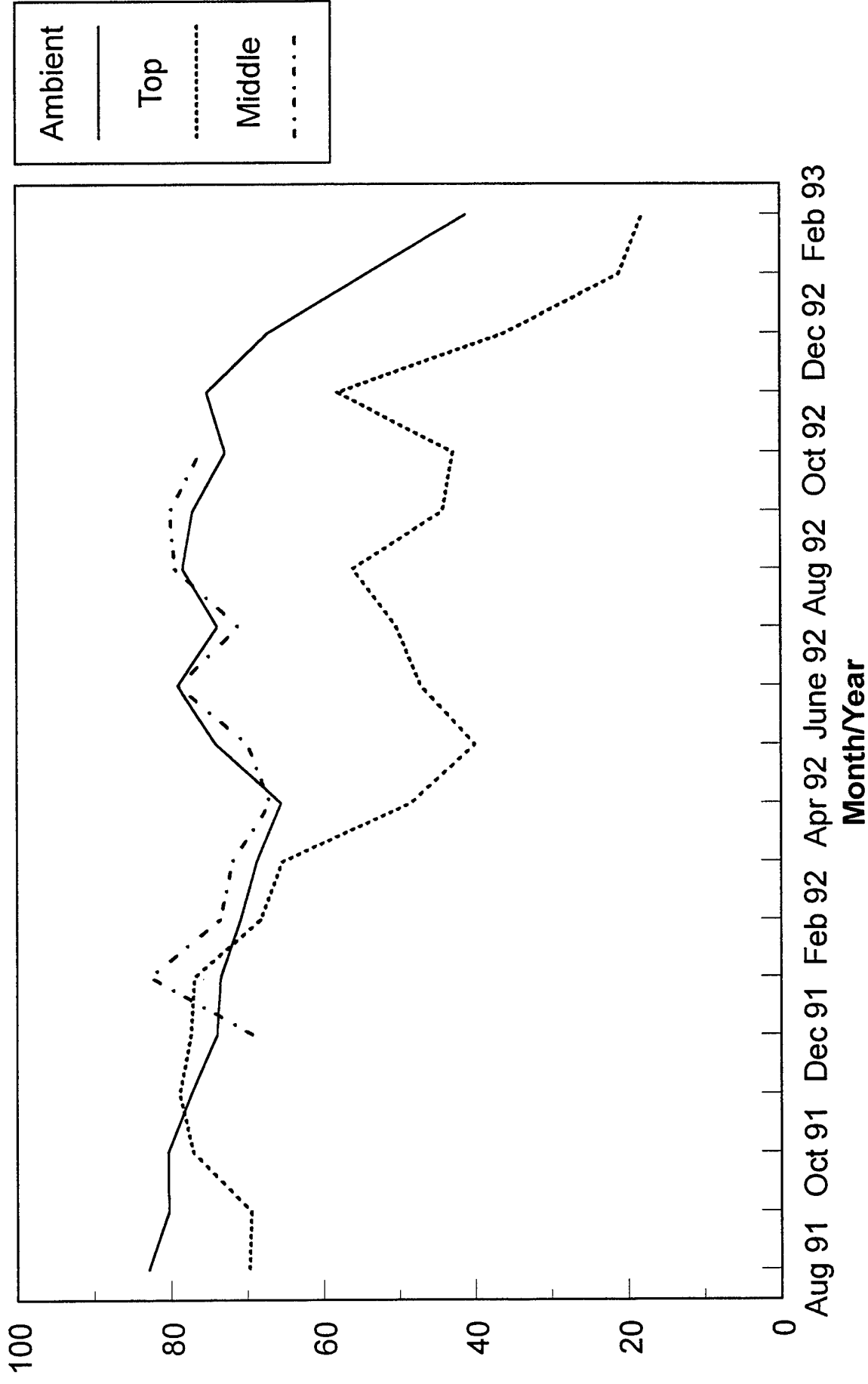
Humidity in Percent



Peak Monthly Humidity for Pallet 23

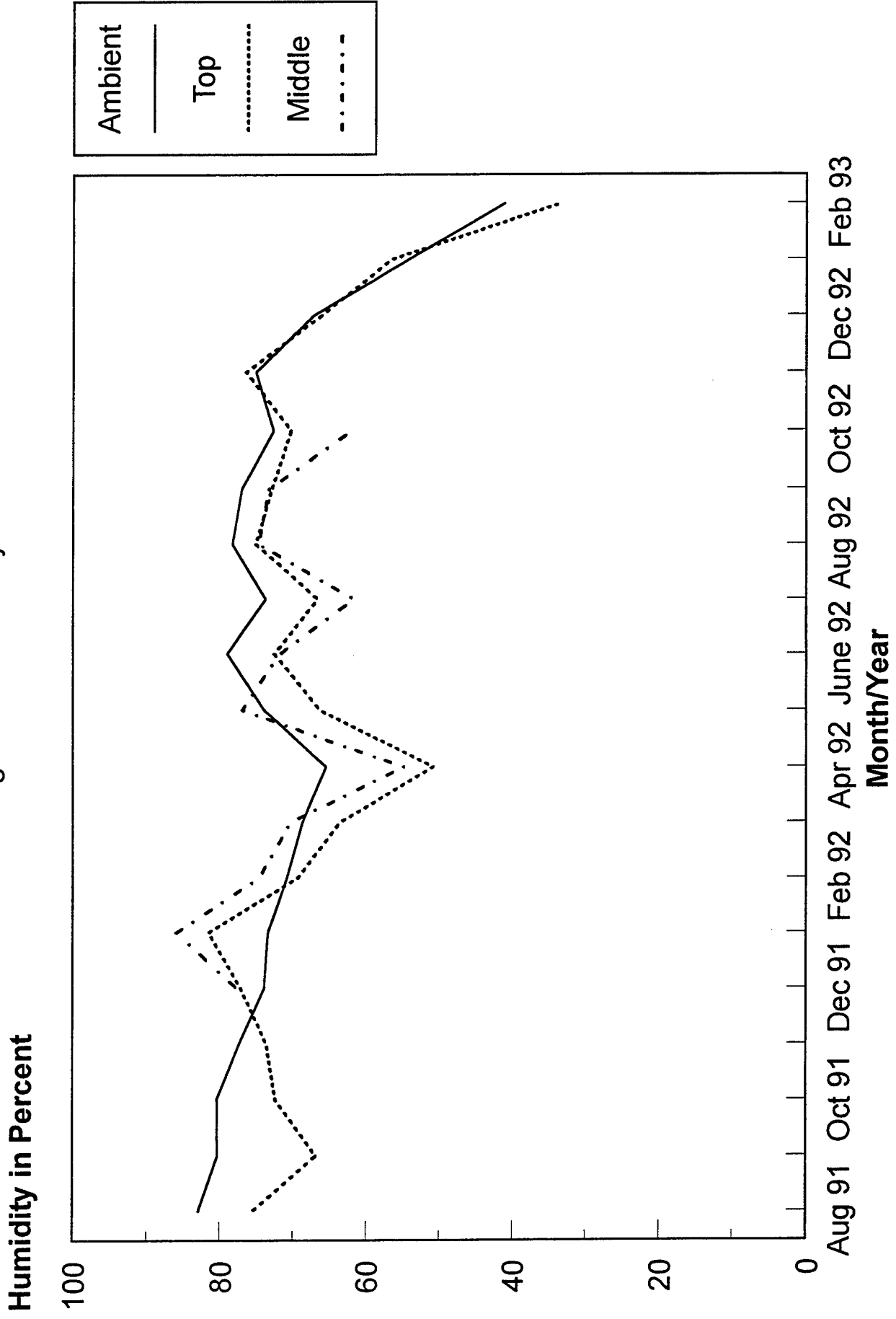
August 91 - February 93

Humidity in Percent



Peak Monthly Humidity for Pallet 28

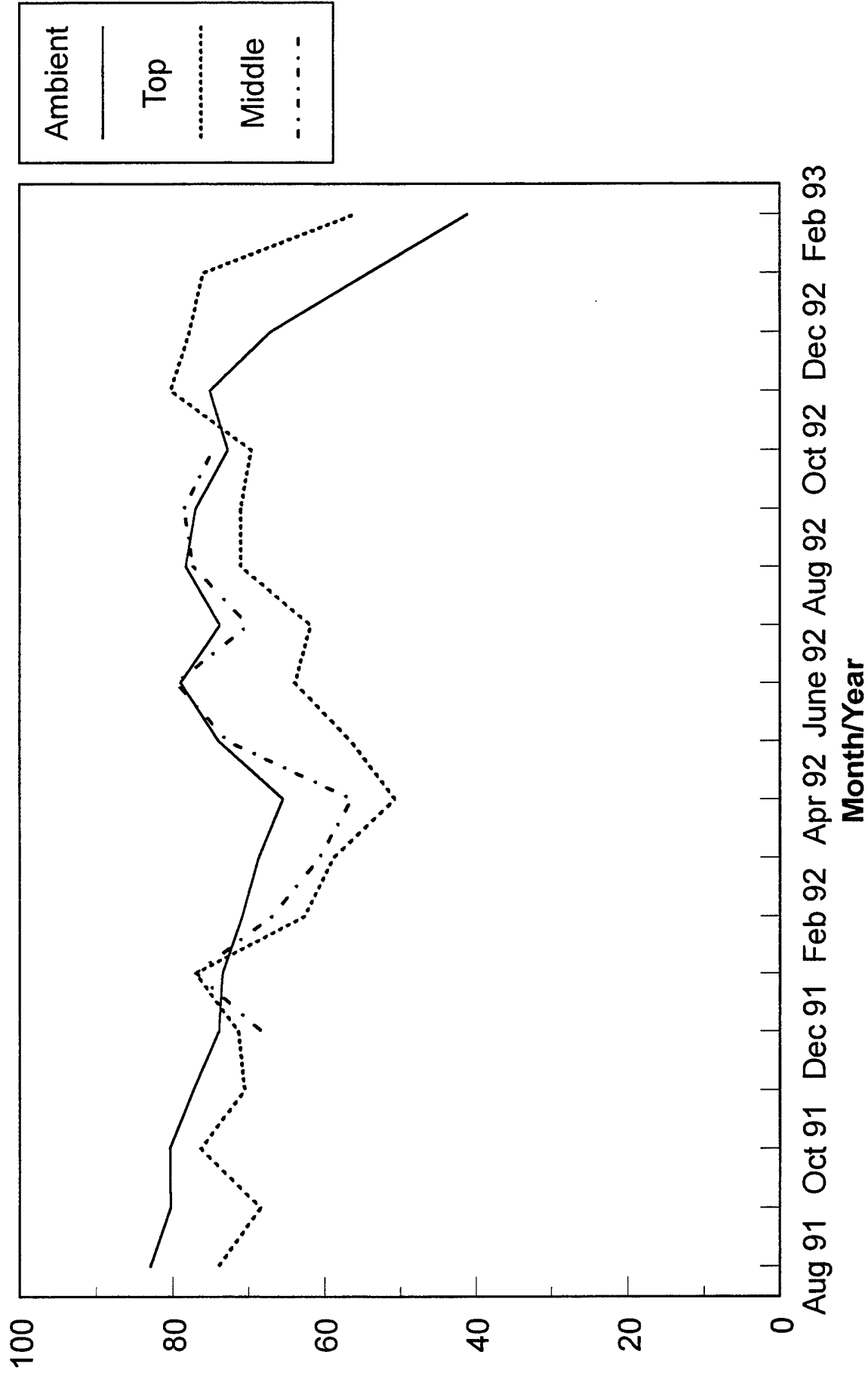
August 91 - February 93



Peak Monthly Humidity for Pallet 2

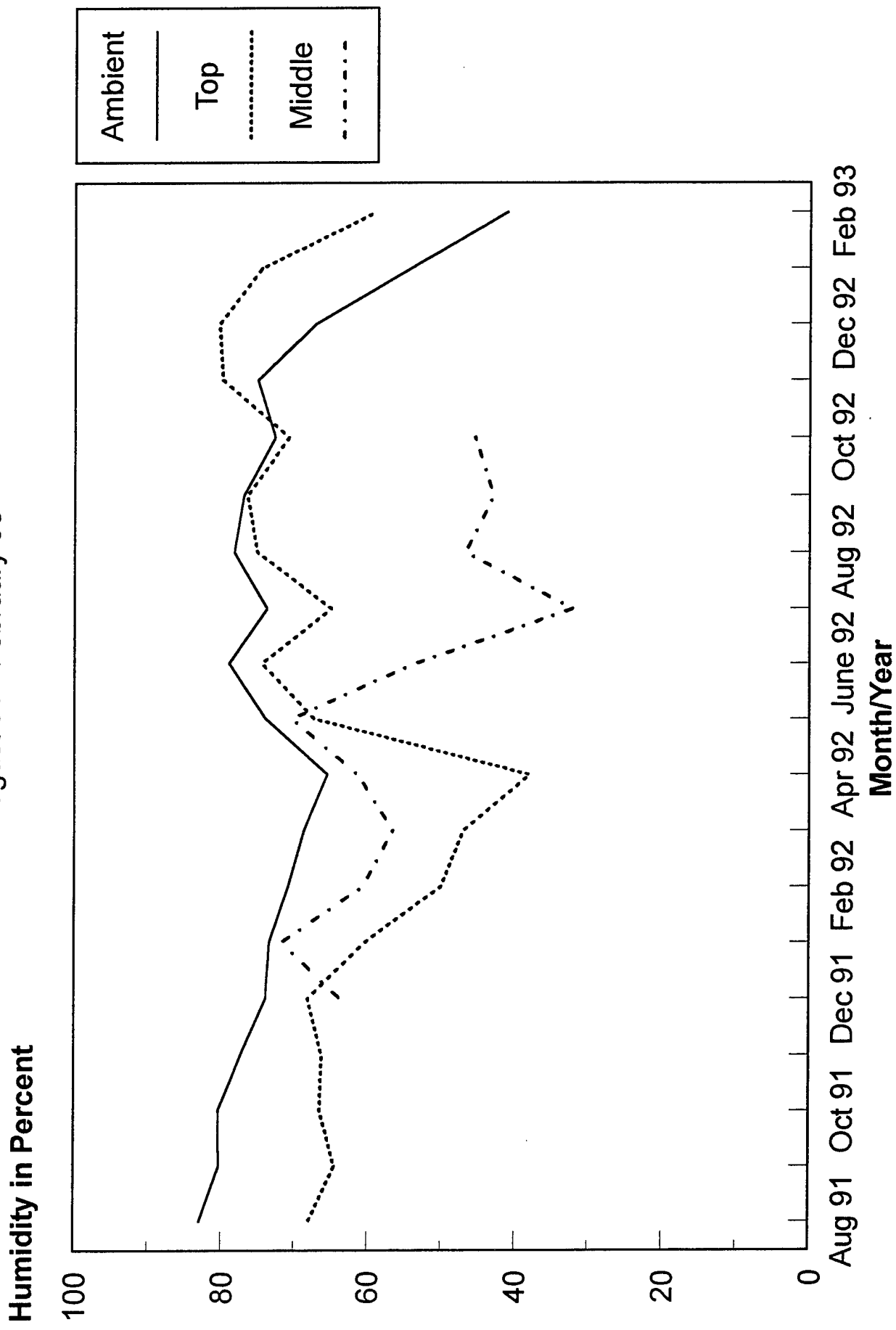
August 91 - February 93

Humidity in Percent



Peak Monthly Humidity for Pallet 4

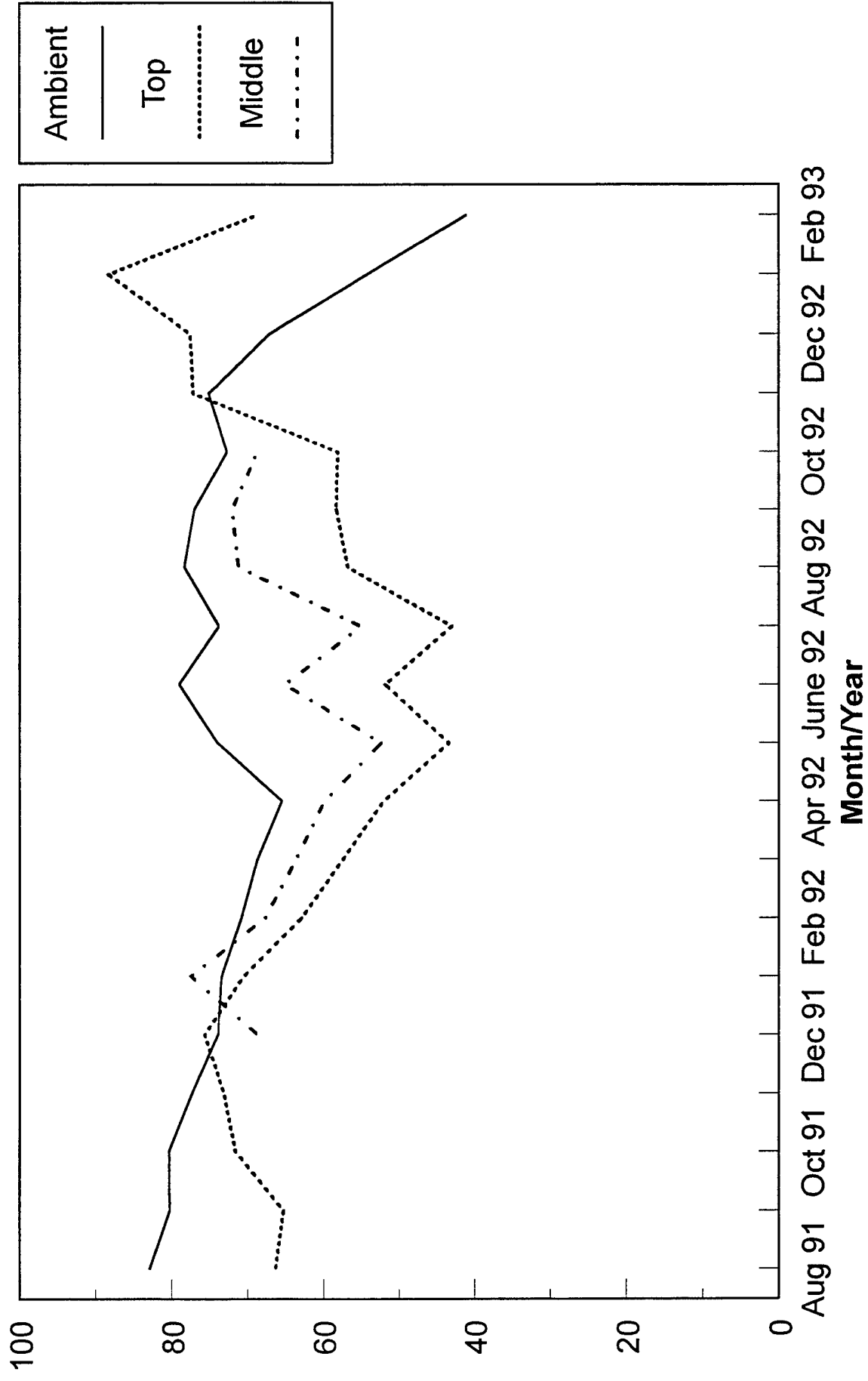
August 91 - February 93



Peak Monthly Humidity for Pallet 7

August 91 - February 93

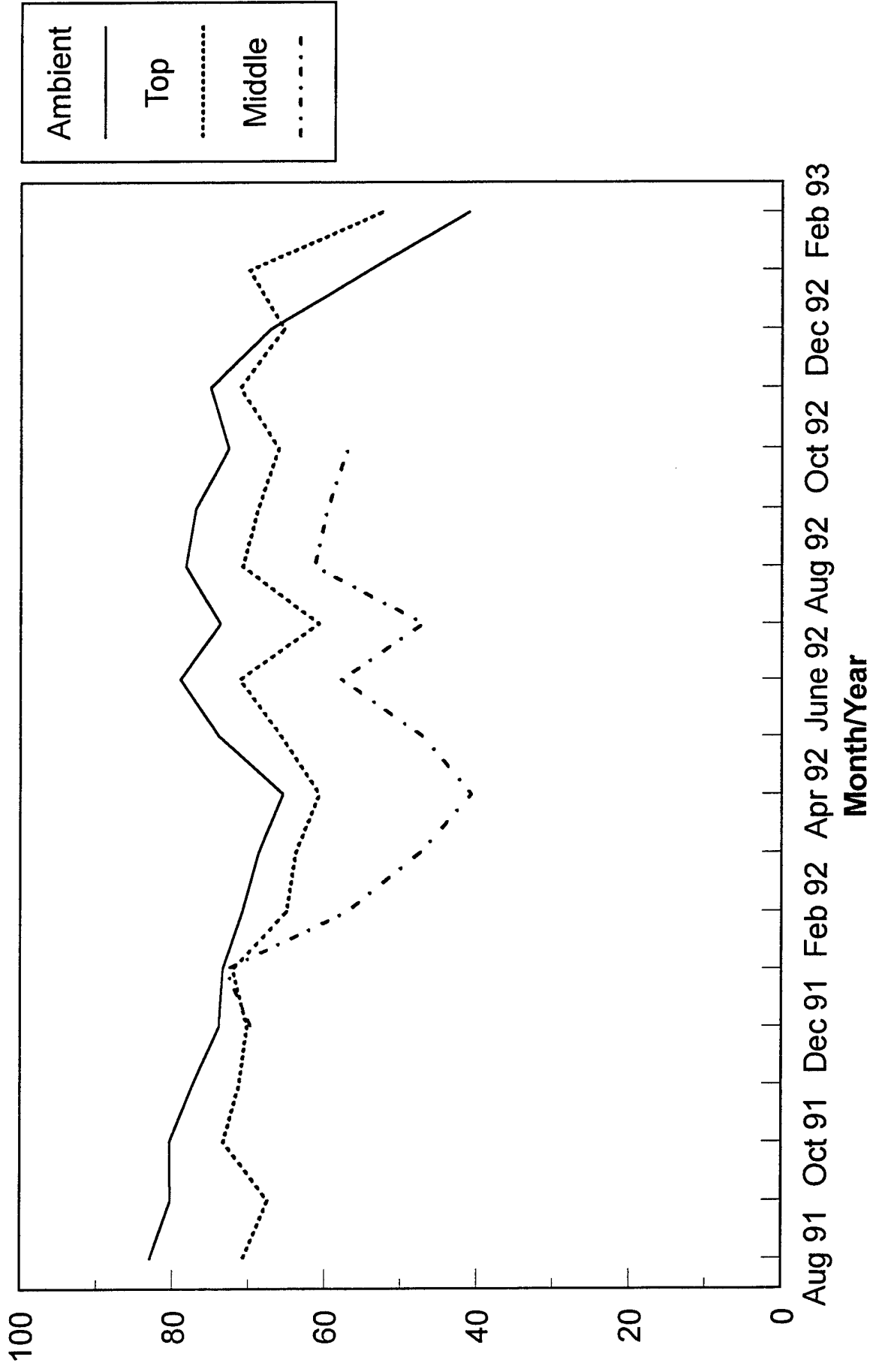
Humidity in Percent



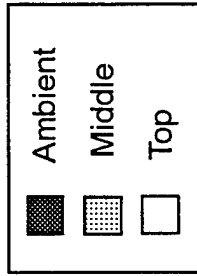
Peak Monthly Humidity for Pallet 9

August 91 - February 93

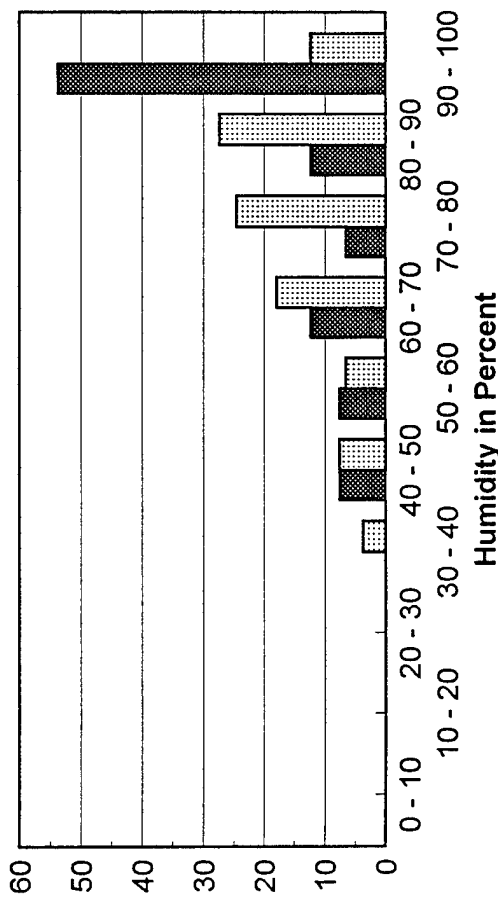
Humidity in Percent



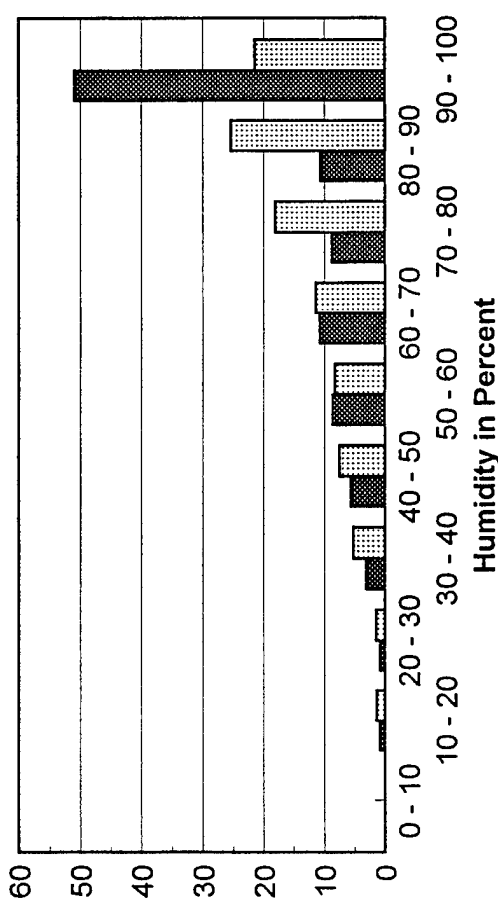
Humidity Histogram for Pallet #24



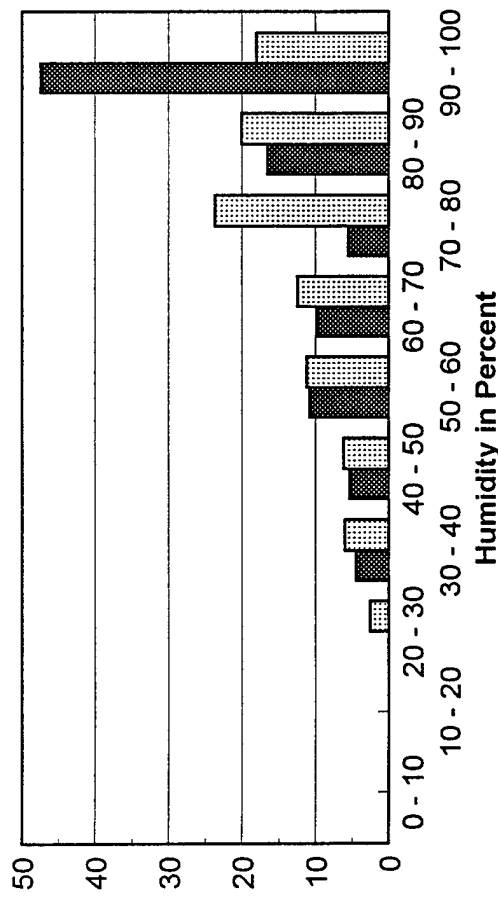
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Occurrences in Percentage



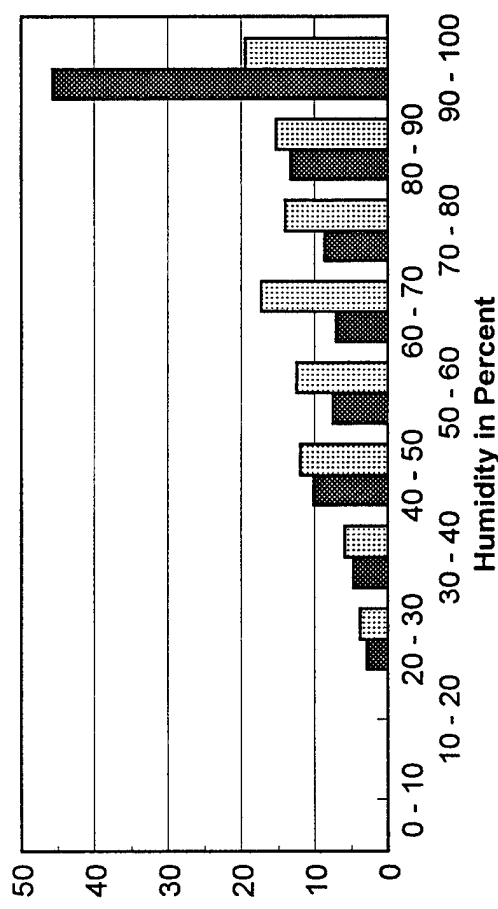
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Occurrences in Percentage



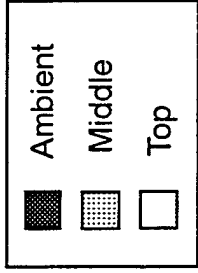
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Occurrences in Percentage



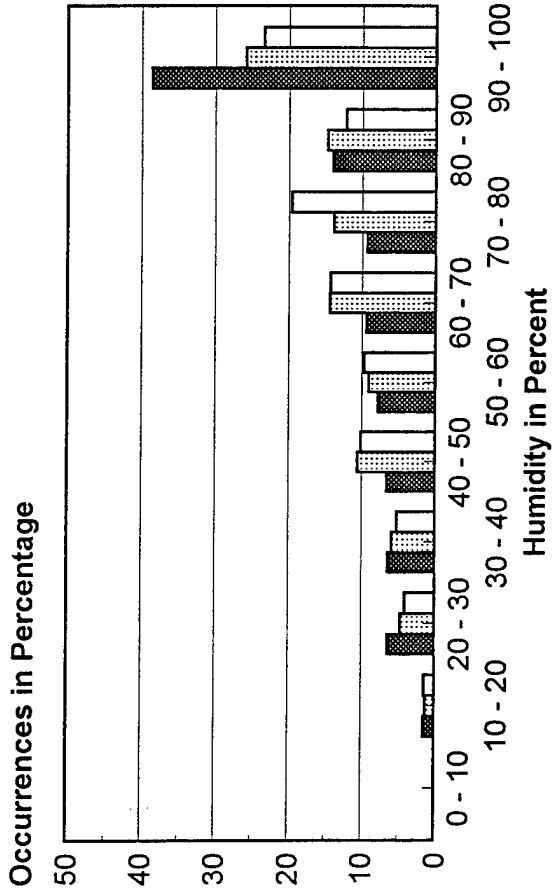
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Occurrences in Percentage



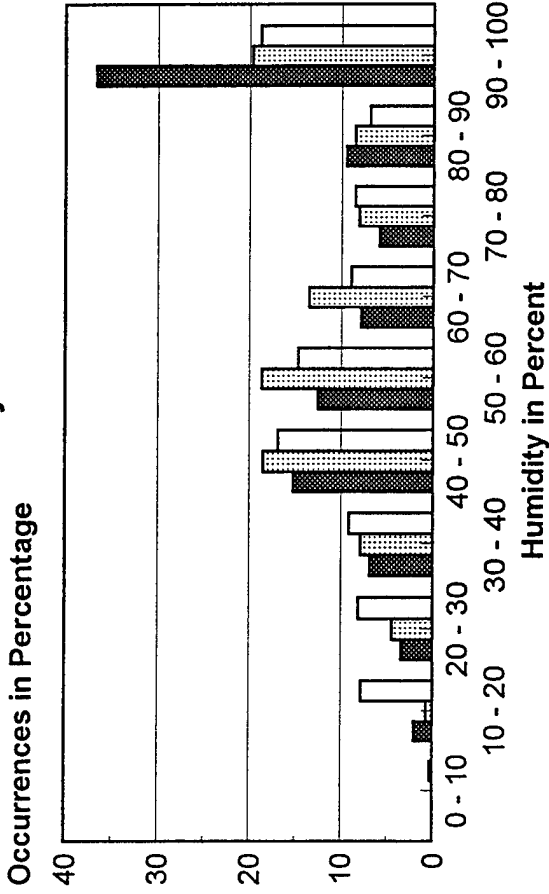
Humidity Histogram for Pallet #24



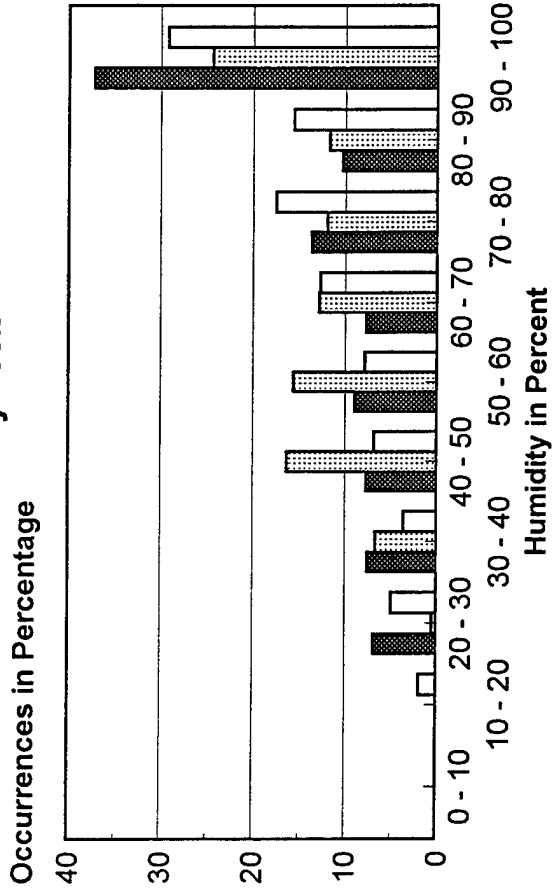
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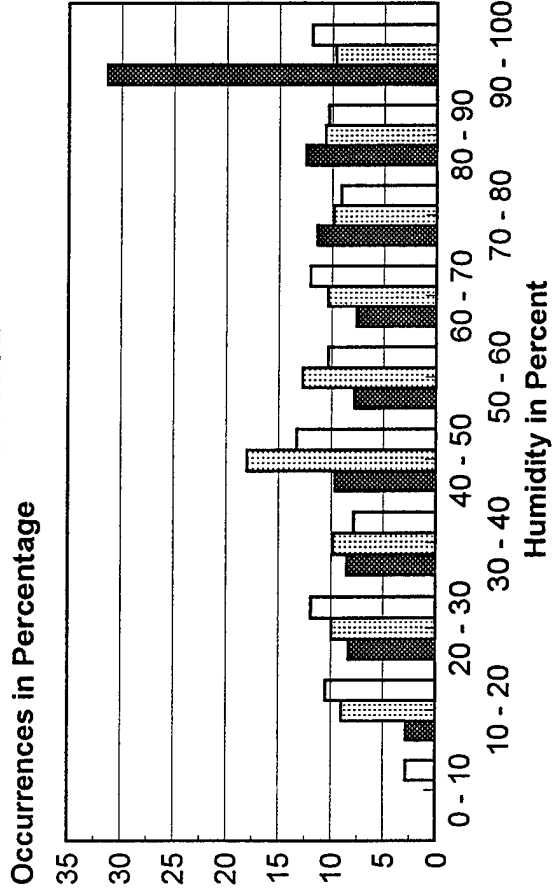
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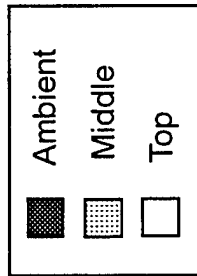
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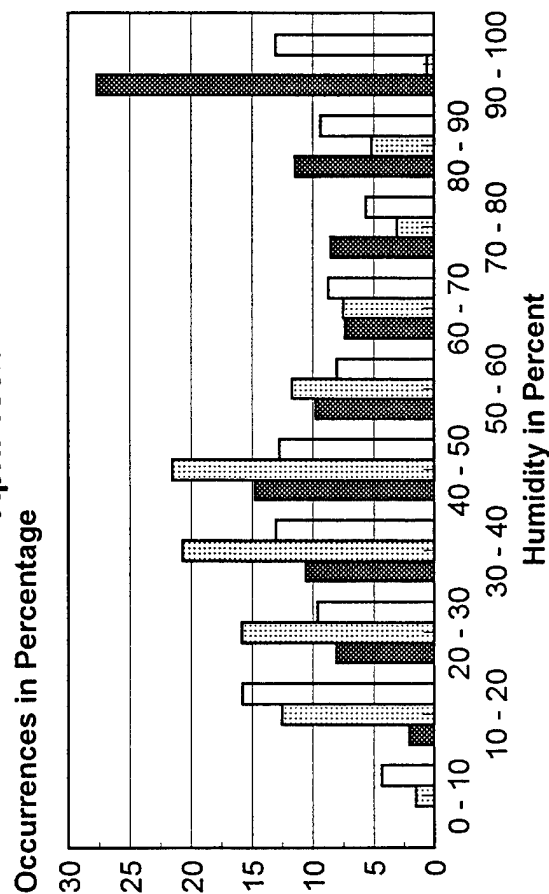
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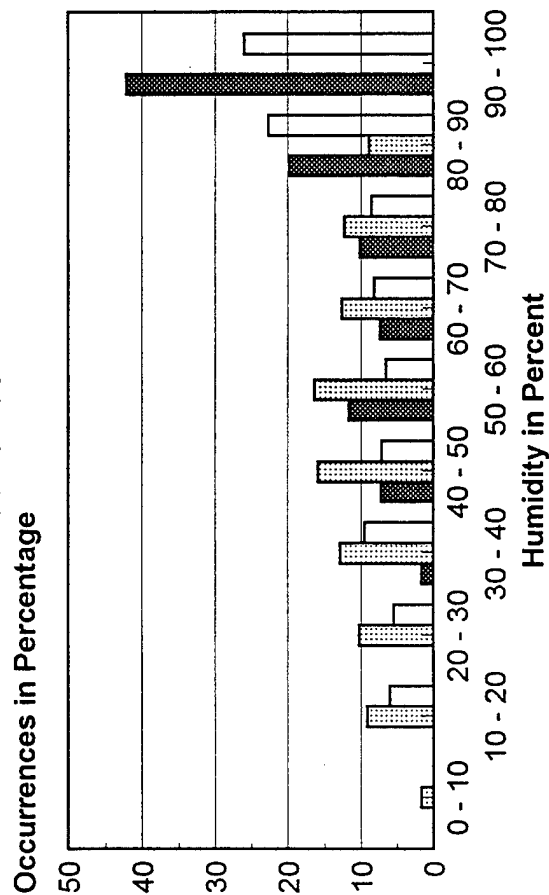
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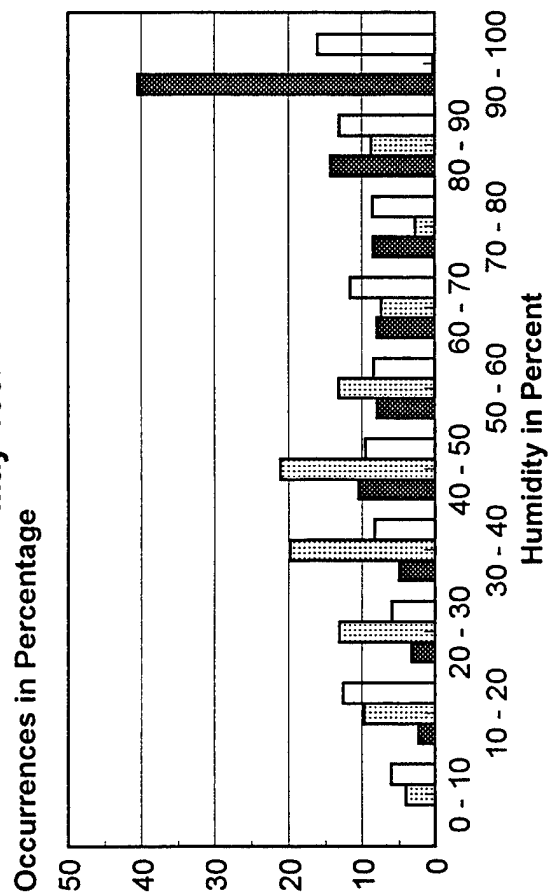
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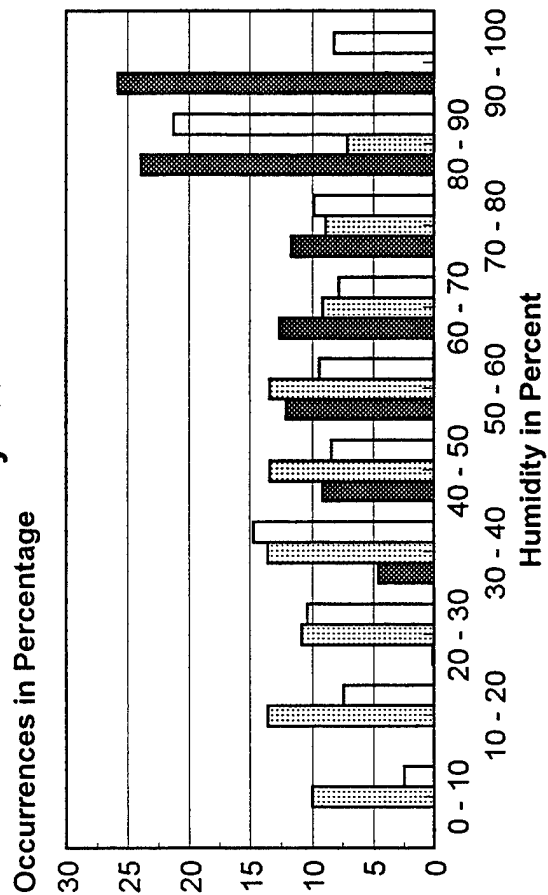
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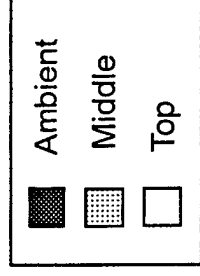
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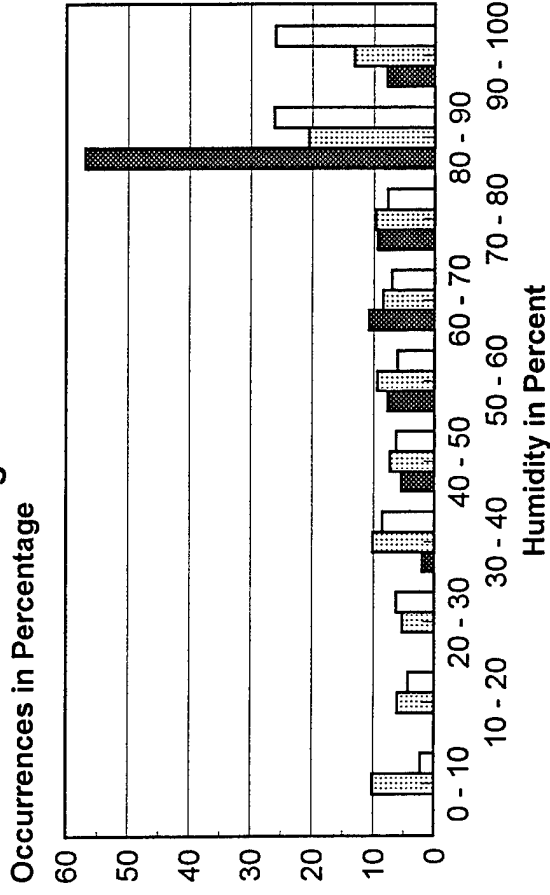
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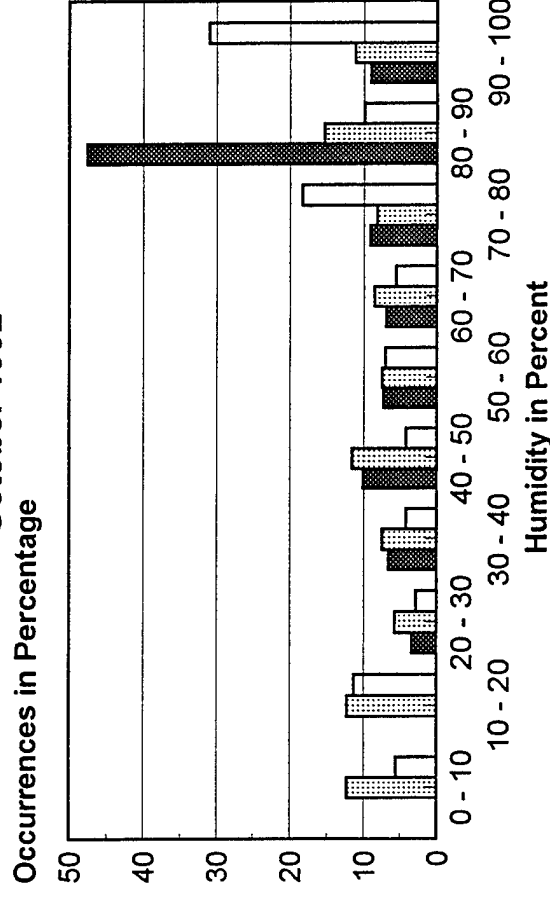
Humidity Histogram for Pallet #24



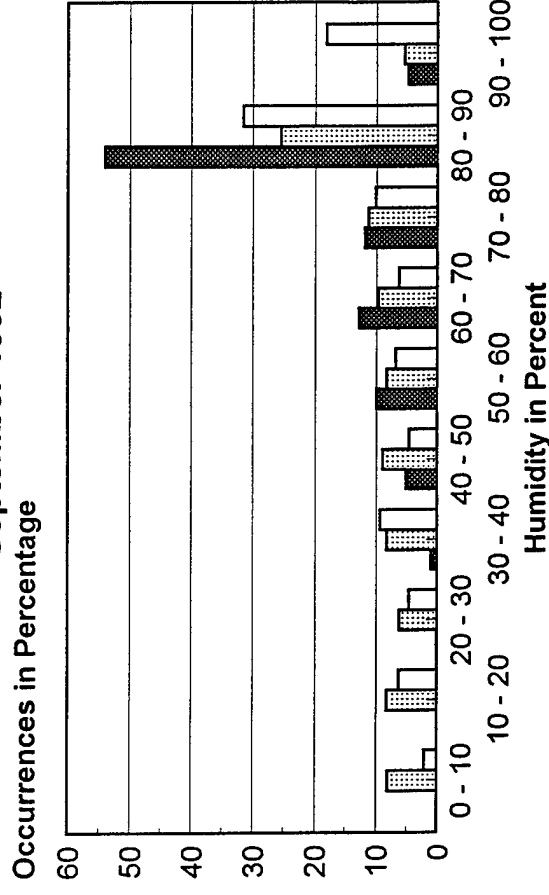
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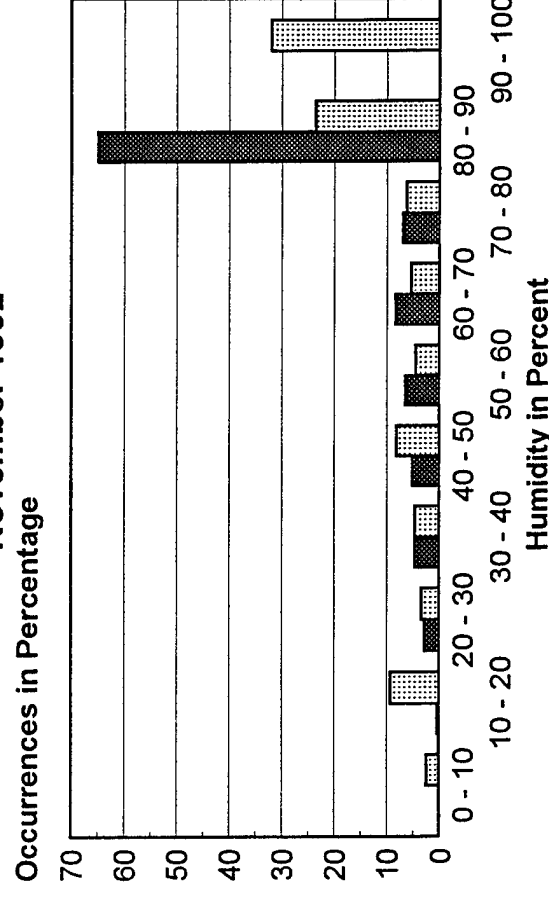
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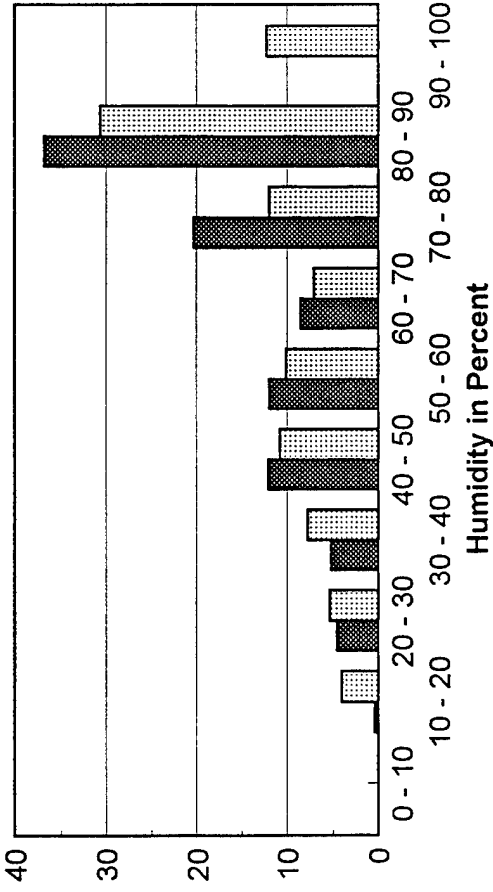


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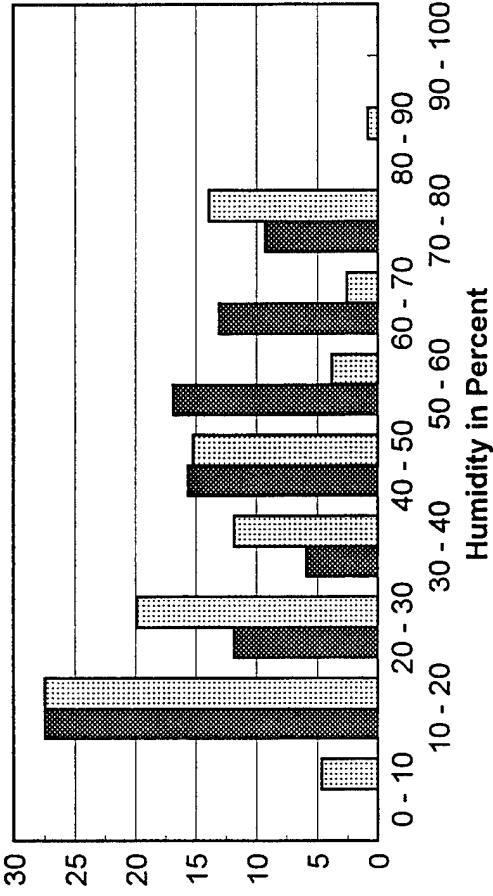


Humidity Histogram for Pallet #24

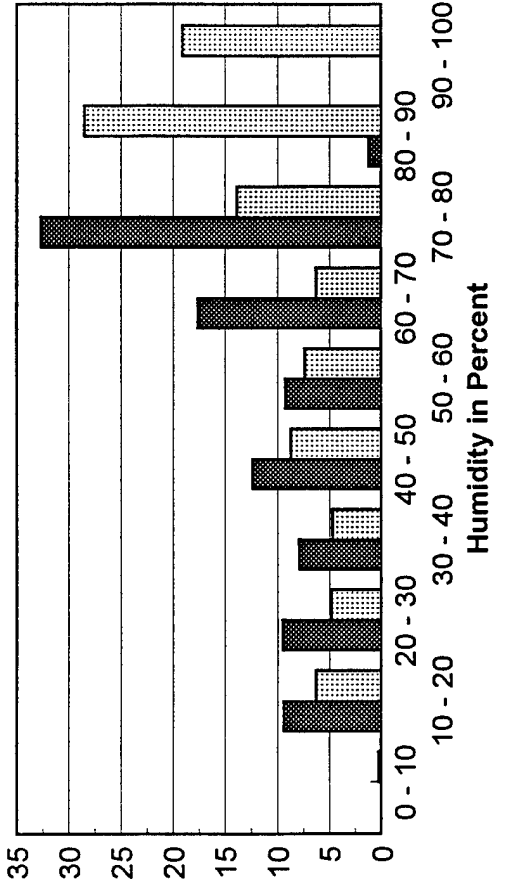
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Occurrences in Percentage



February 1993
Occurrences in Percentage

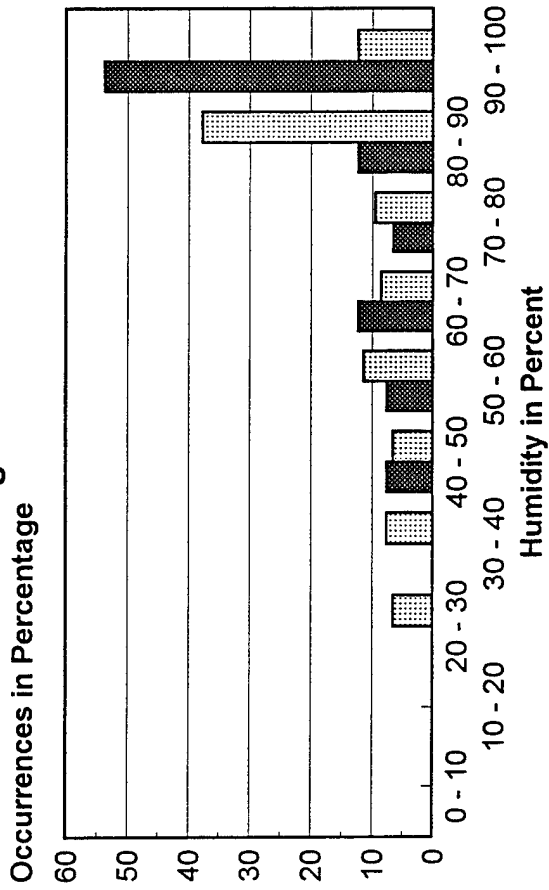


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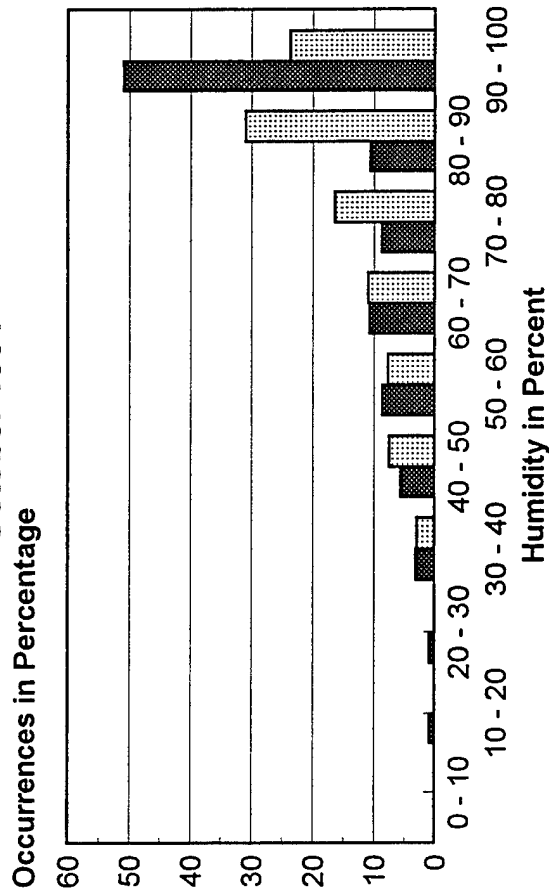


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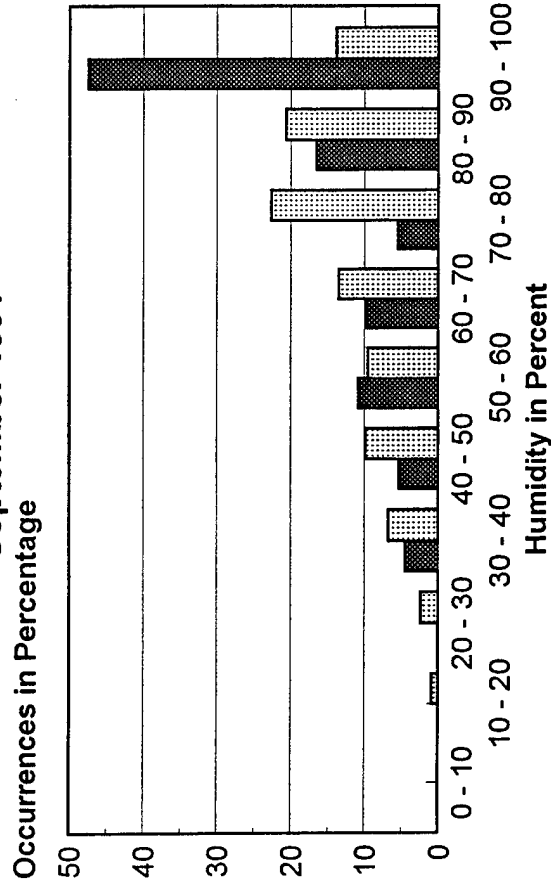
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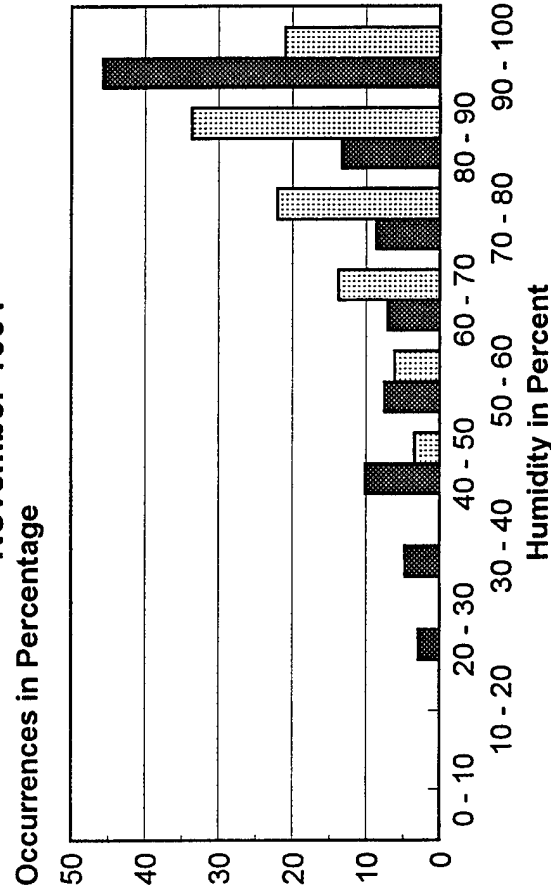
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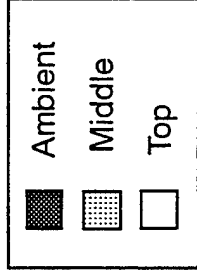
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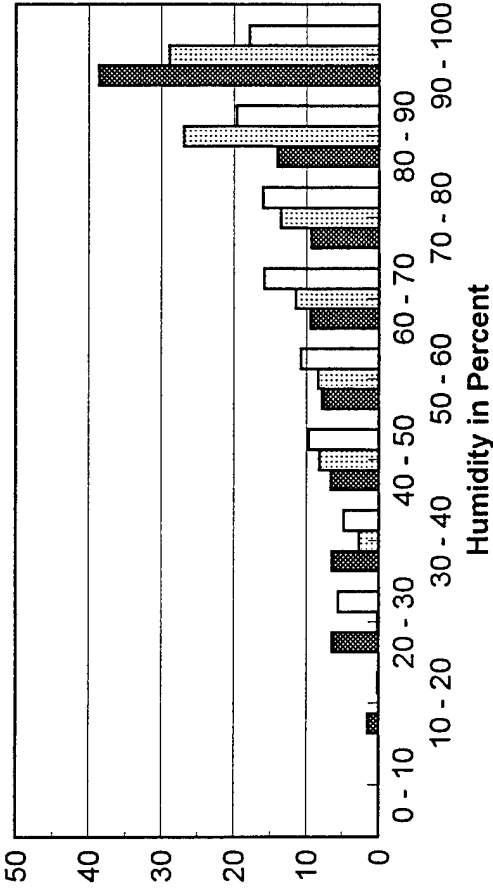
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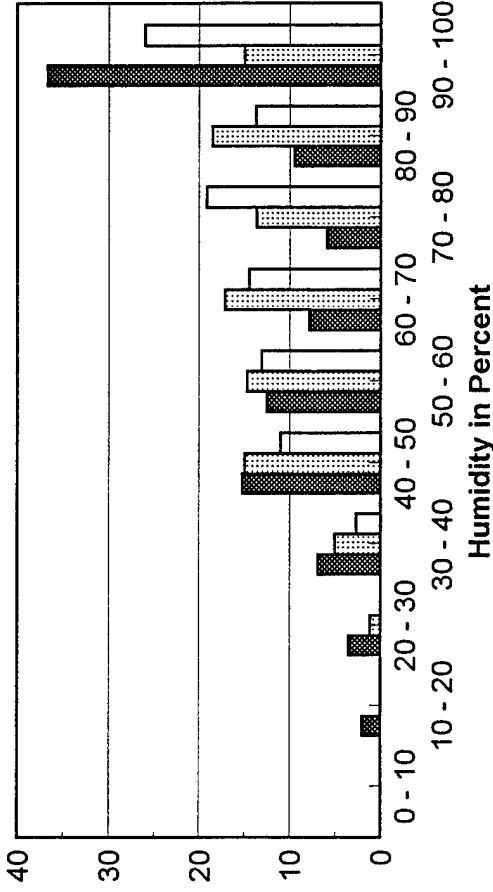
Humidity Histogram for Pallet #23



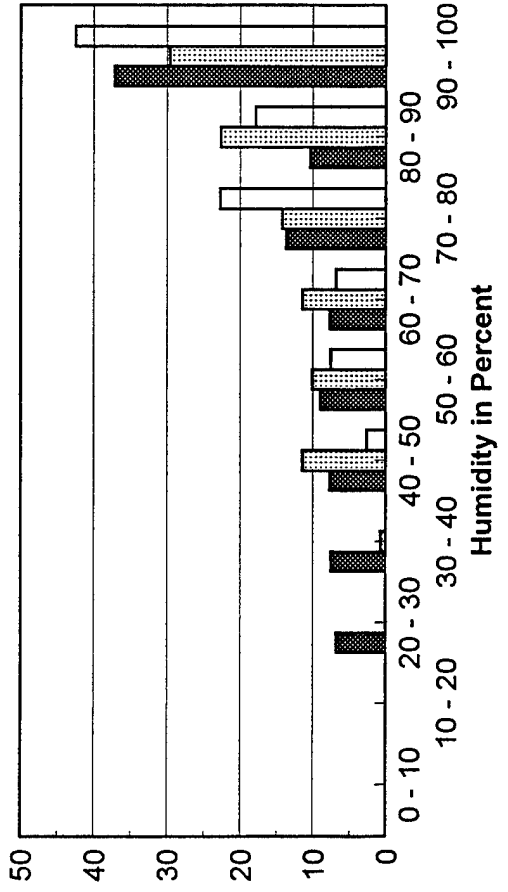
December 1991
Occurrences in Percentage



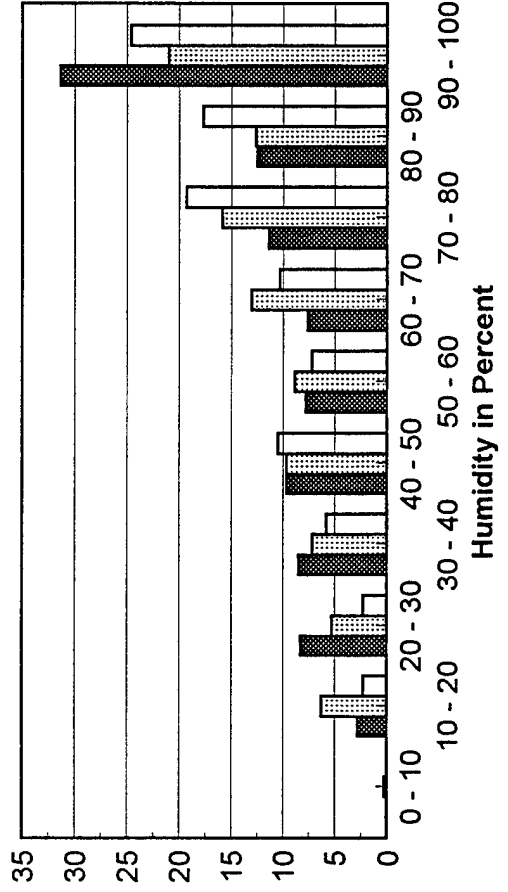
February 1992
Occurrences in Percentage



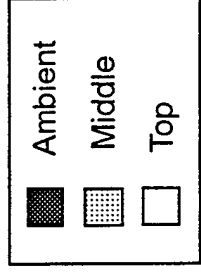
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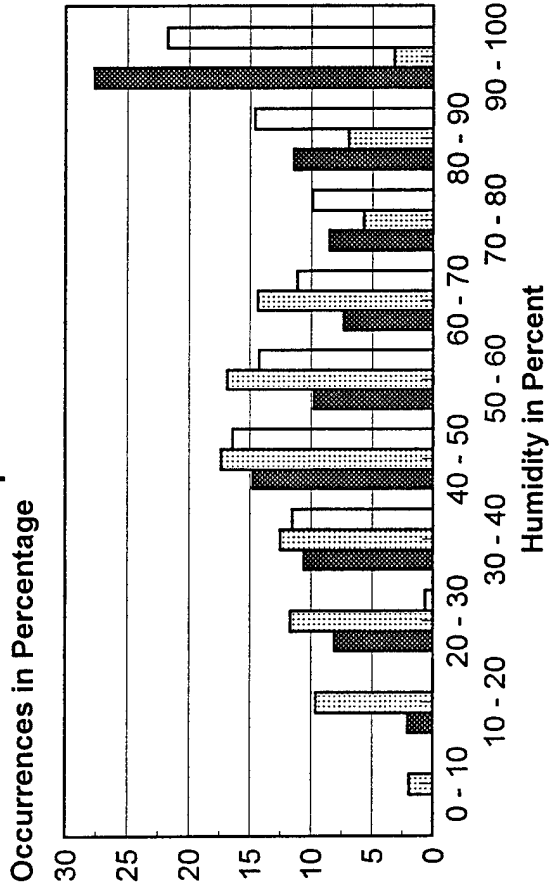
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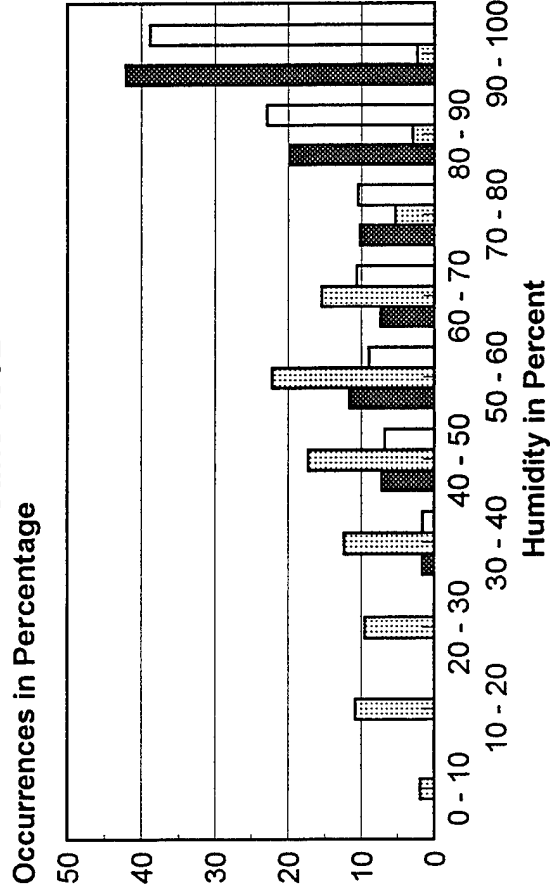
Humidity Histogram for Pallet #23



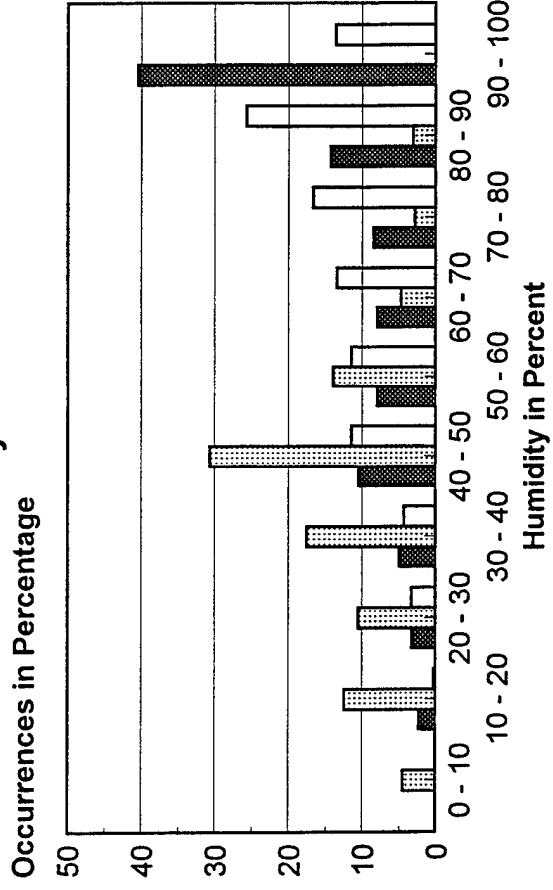
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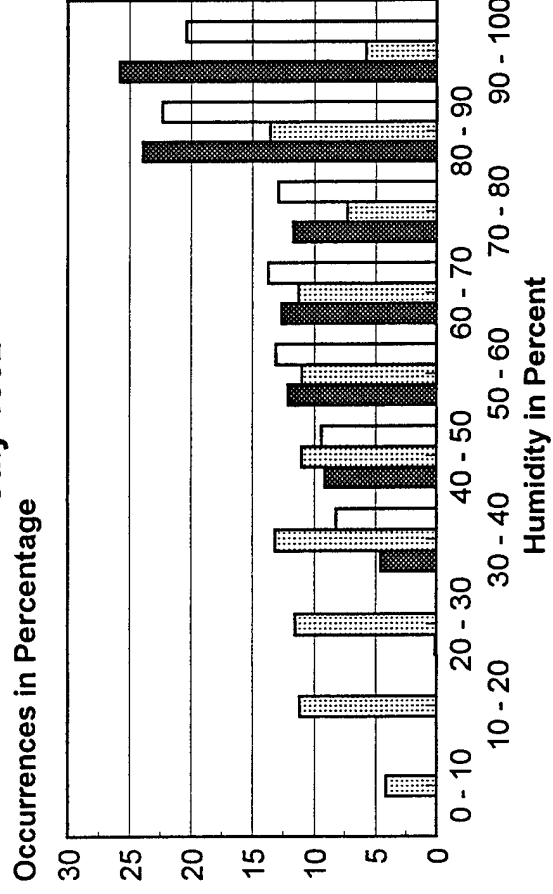
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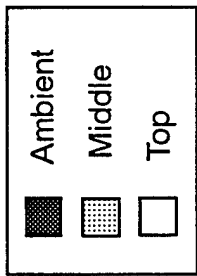
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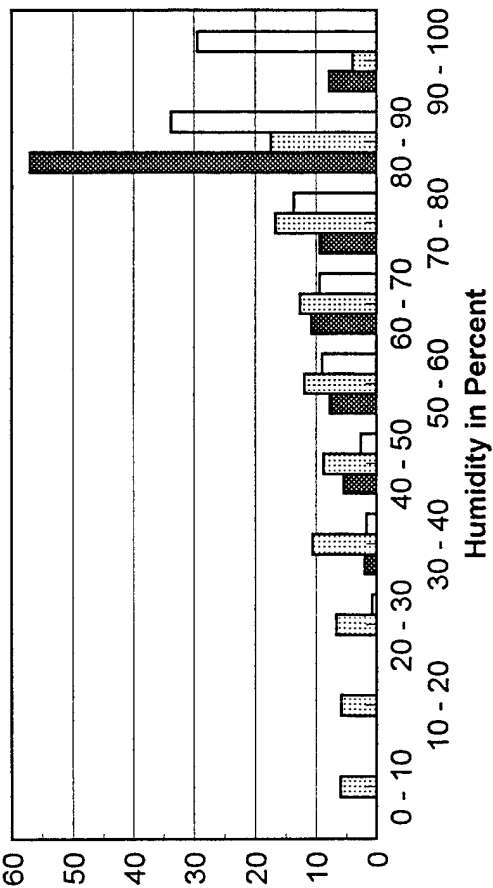
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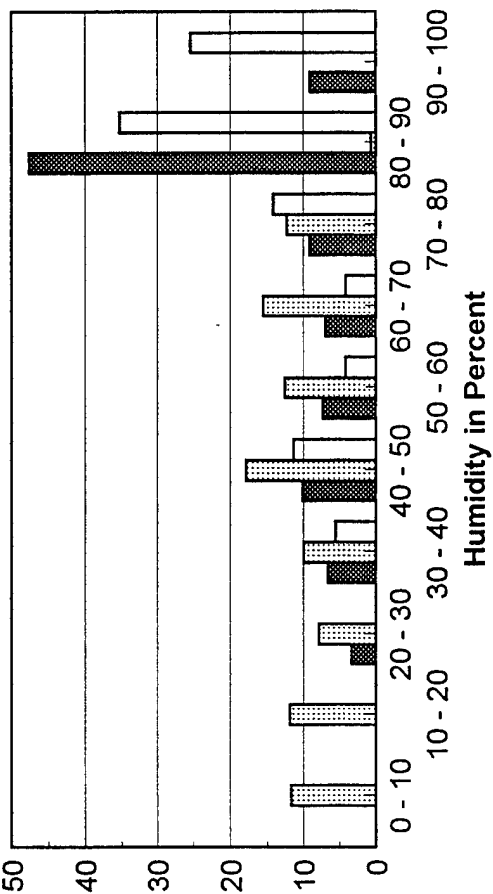
Humidity Histogram for Pallet #23



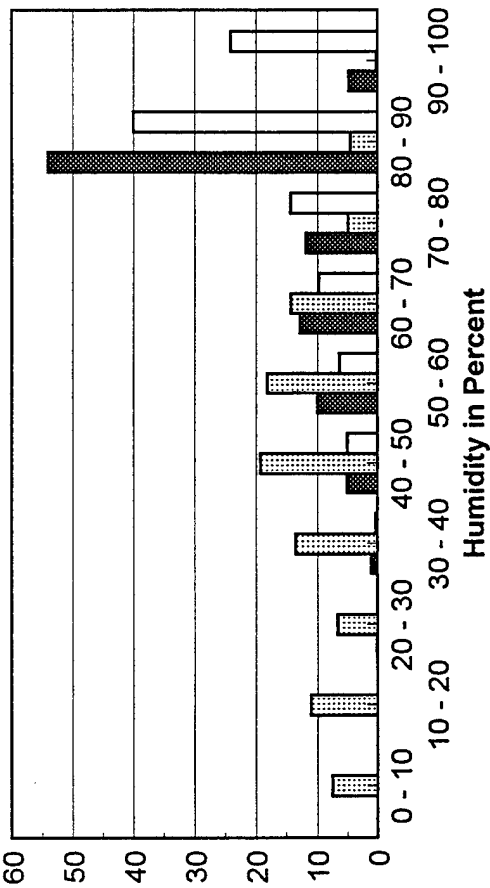
August 1992
Occurrences in Percentage



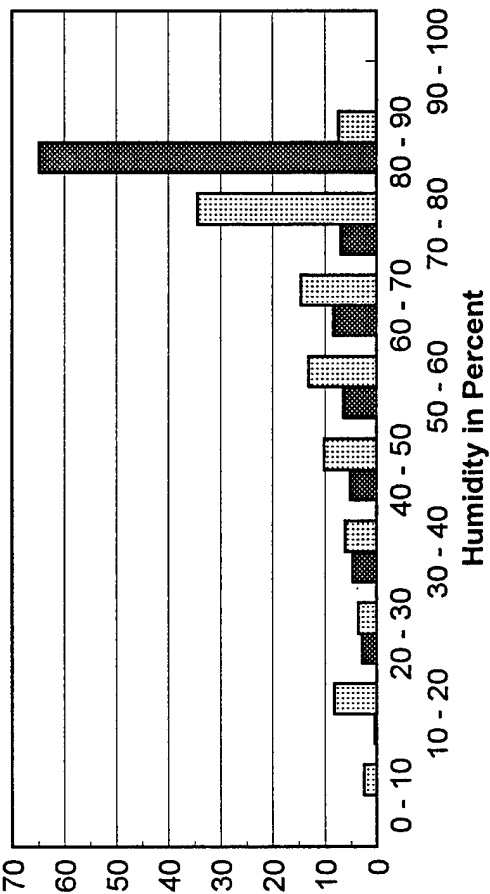
October 1992
Occurrences in Percentage



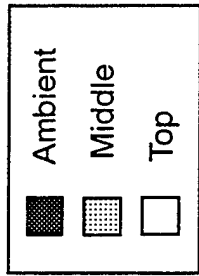
September 1992
Occurrences in Percentage



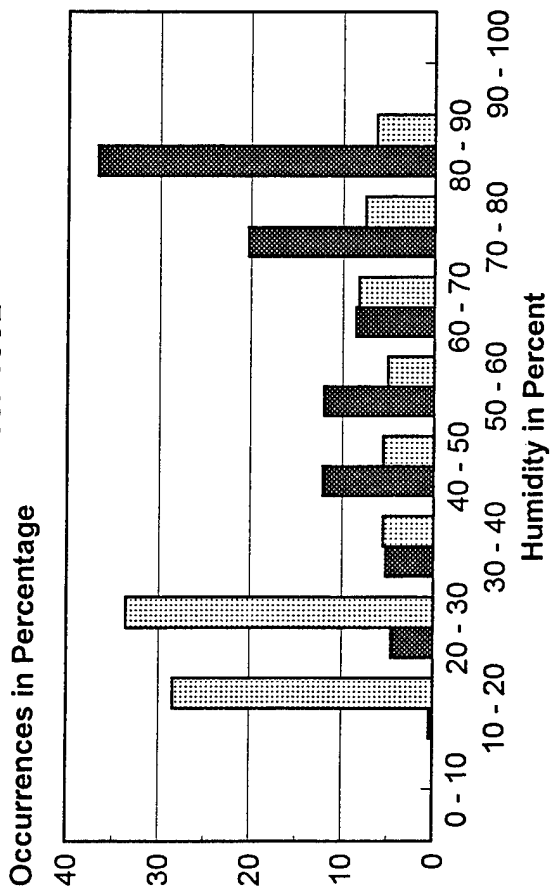
November 1992
Occurrences in Percentage



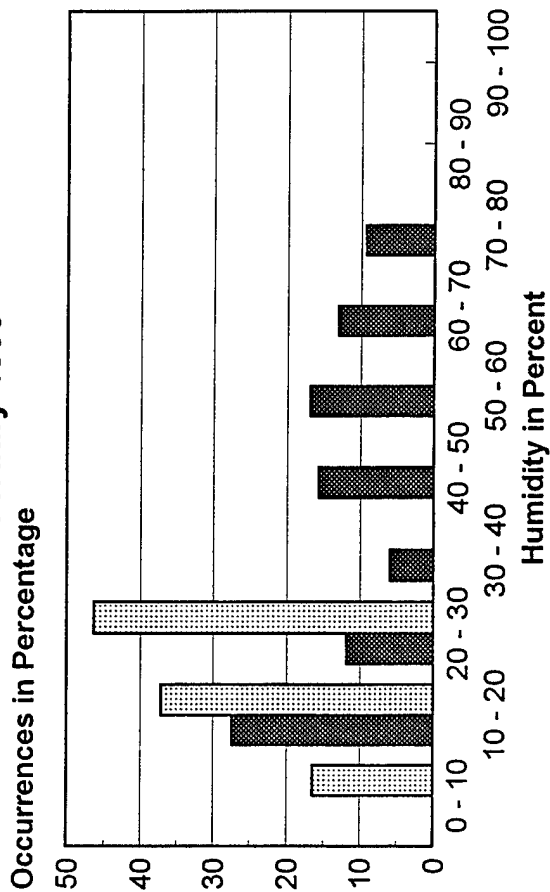
Humidity Histogram for Pallet #23



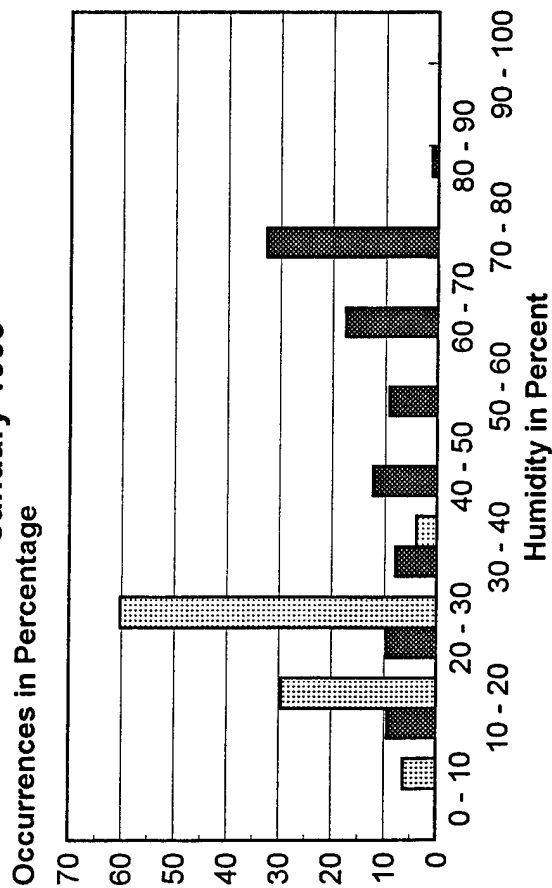
December 1992



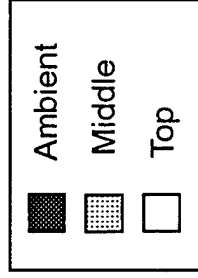
February 1993



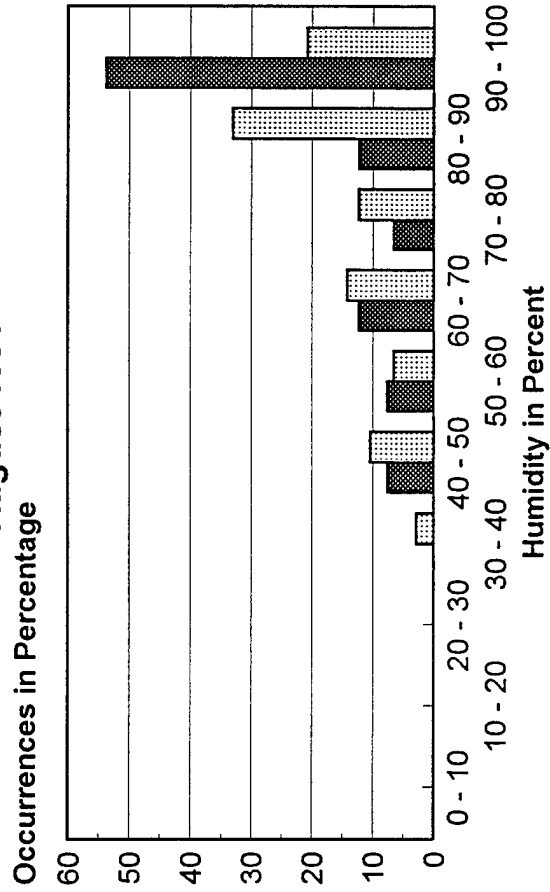
January 1993



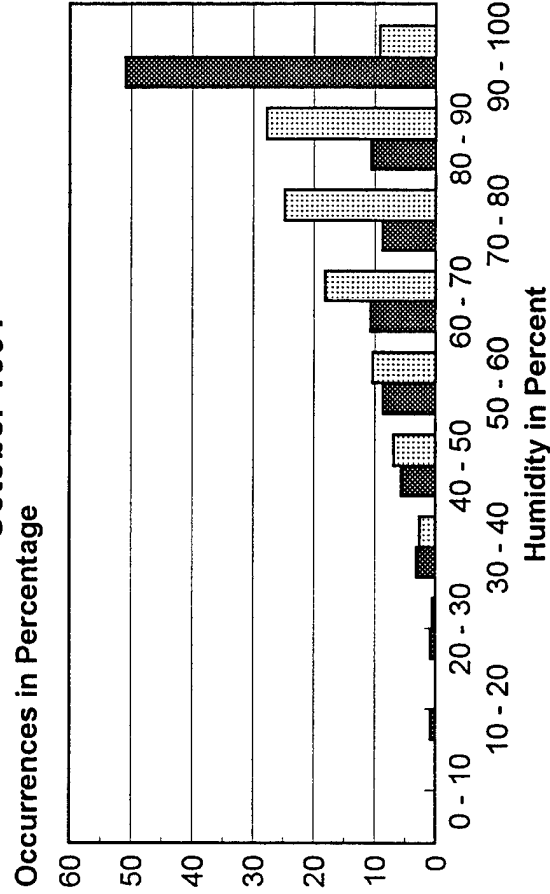
Humidity Histogram for Pallet #28



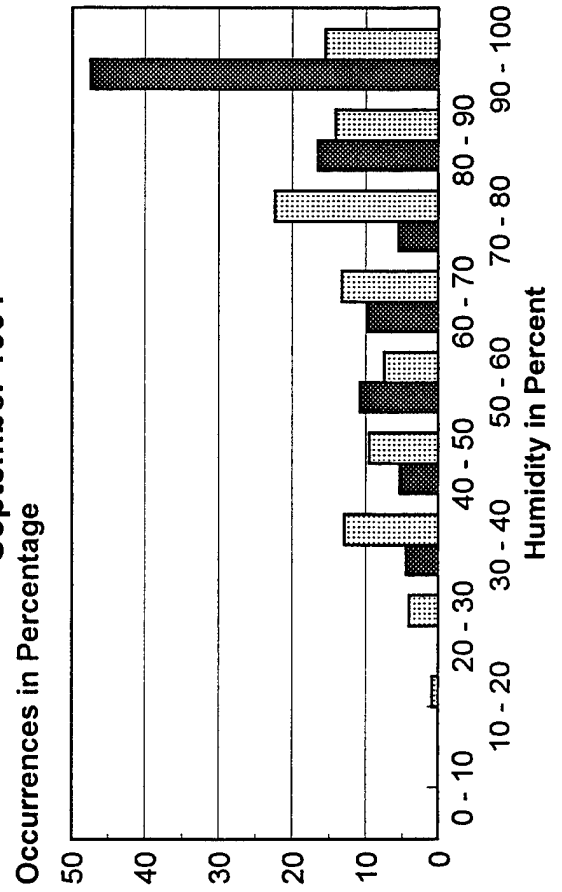
August 1991



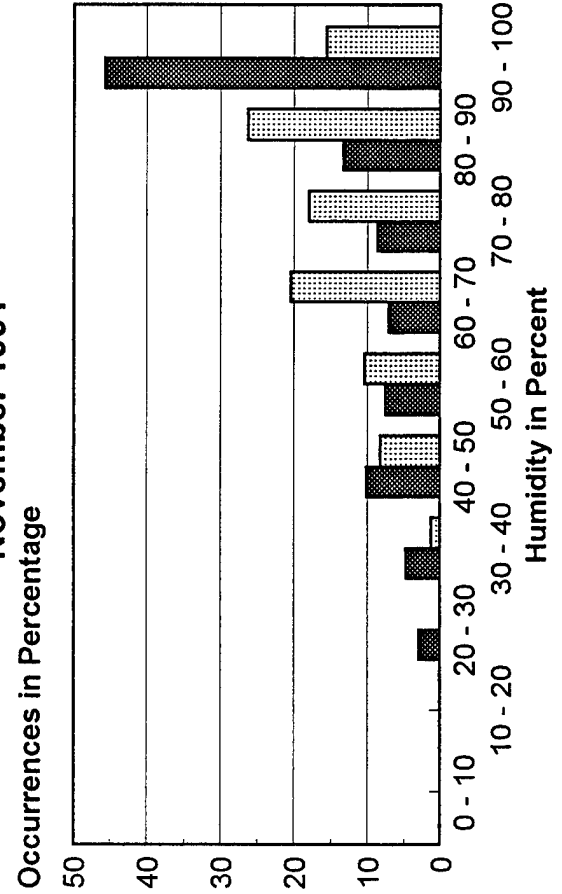
October 1991



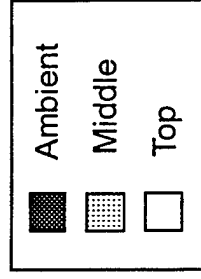
September 1991



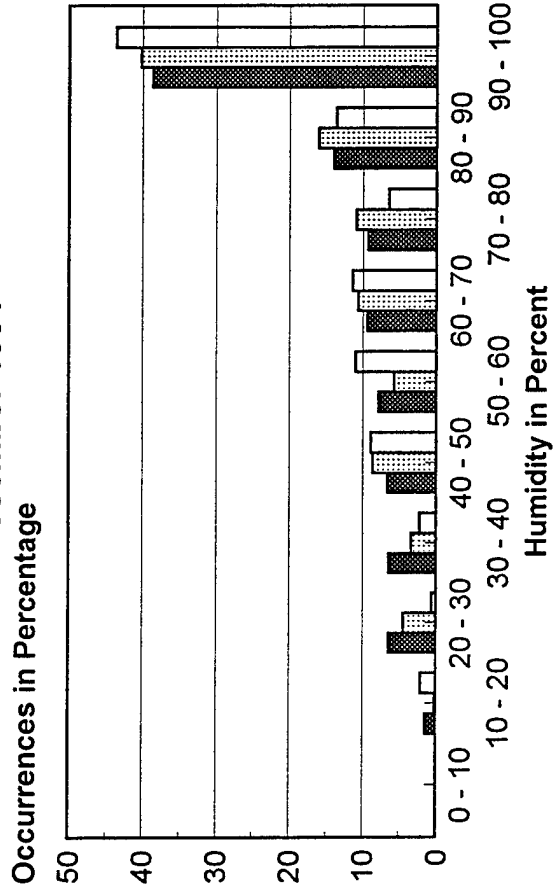
November 1991



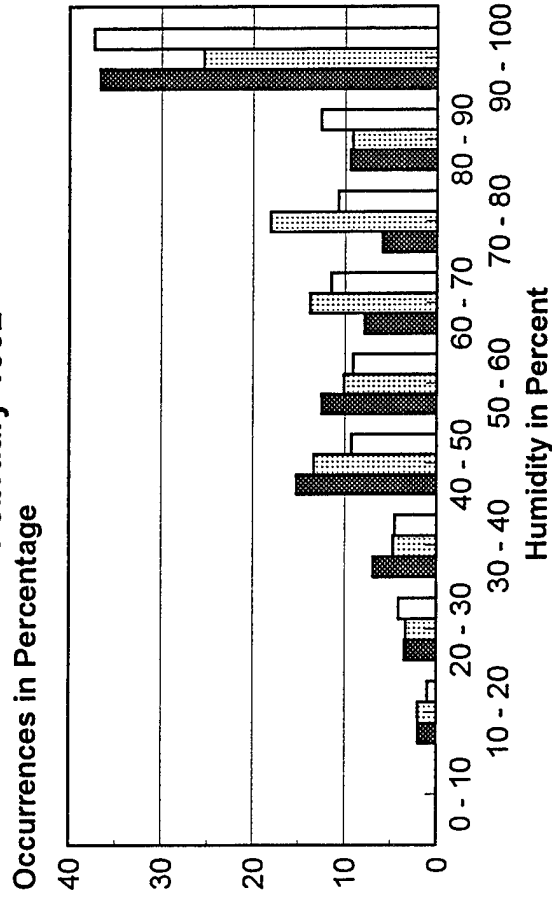
Humidity Histogram for Pallet #28



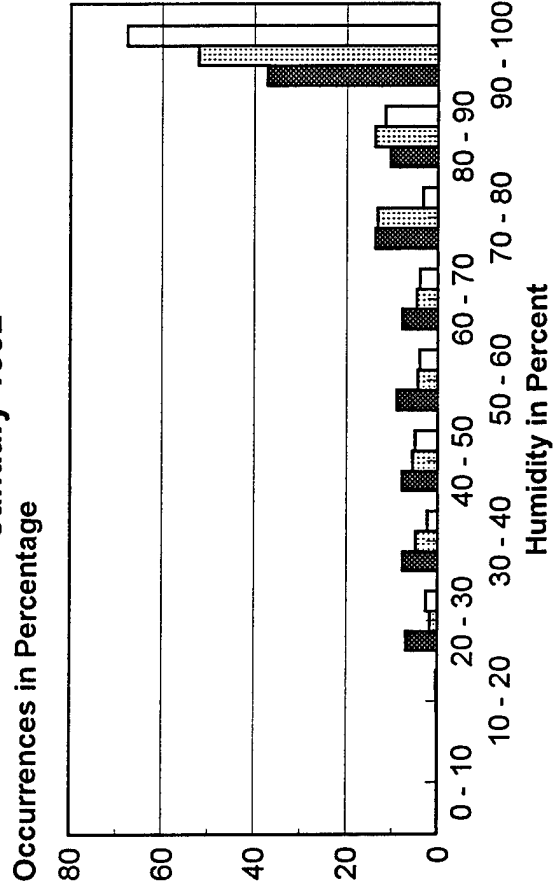
December 1991



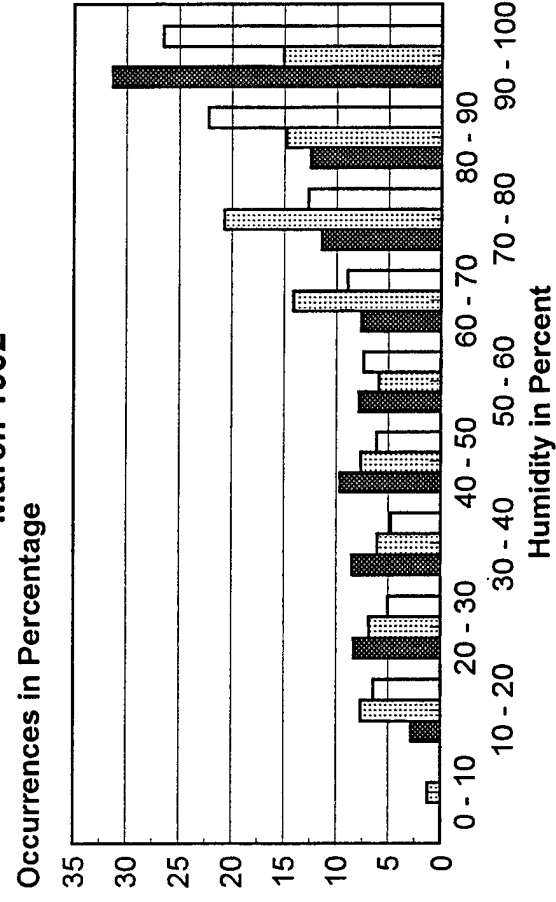
February 1992



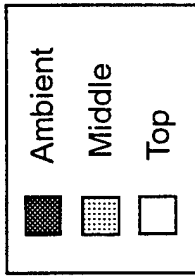
January 1992



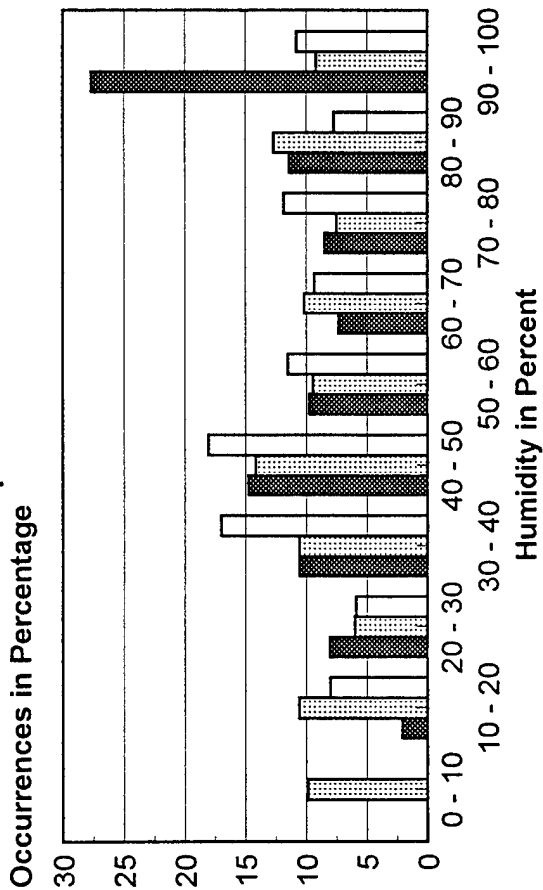
March 1992



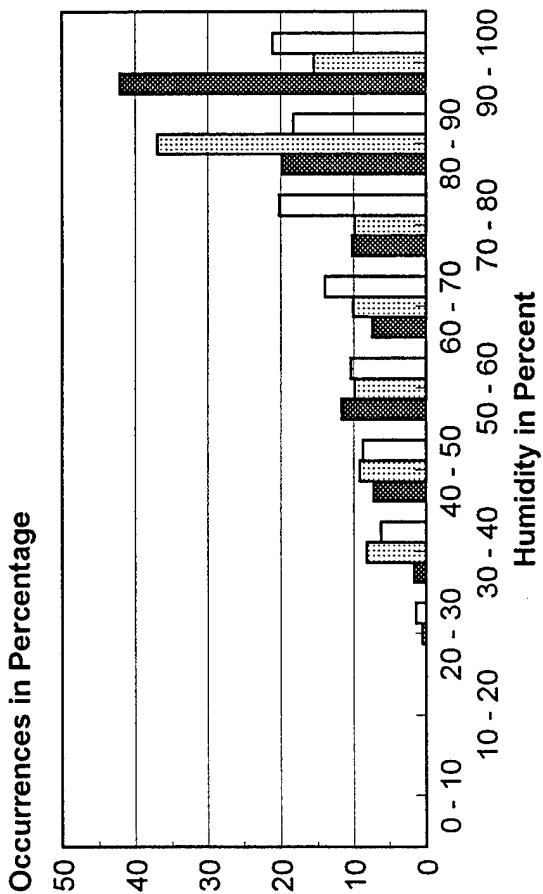
Humidity Histogram for Pallet #28



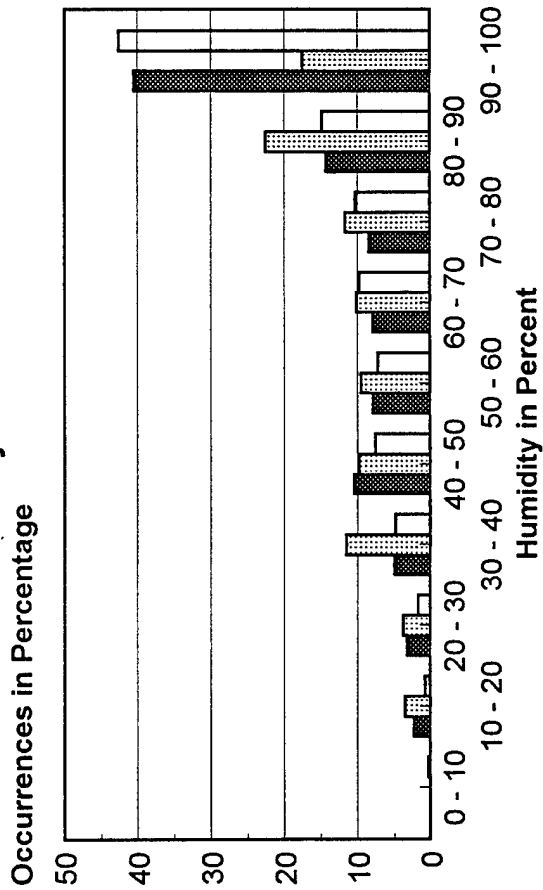
April 1992



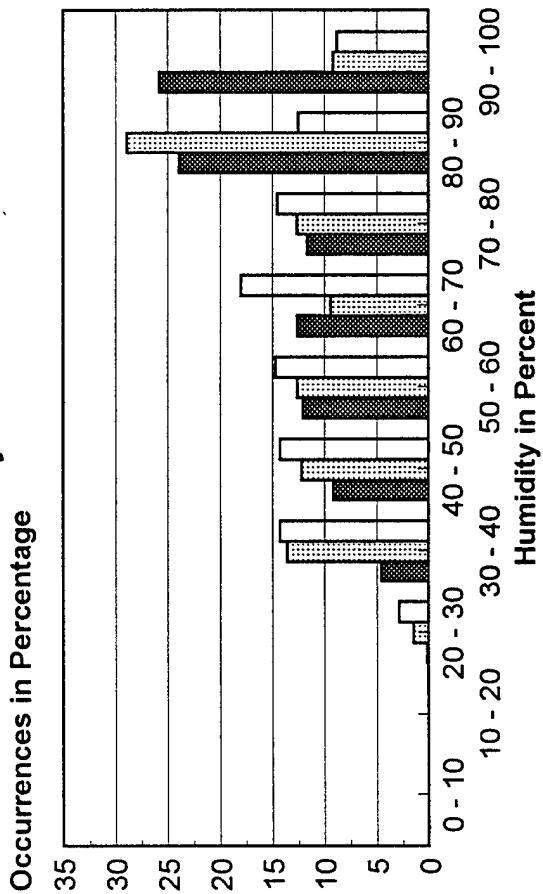
June 1992



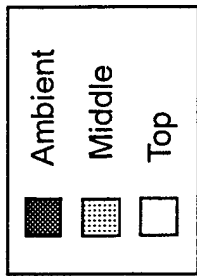
May 1992



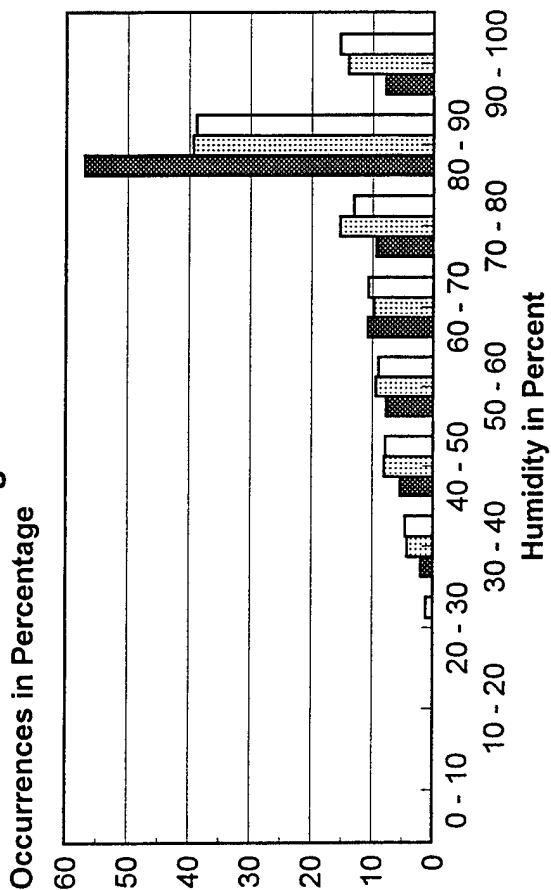
July 1992



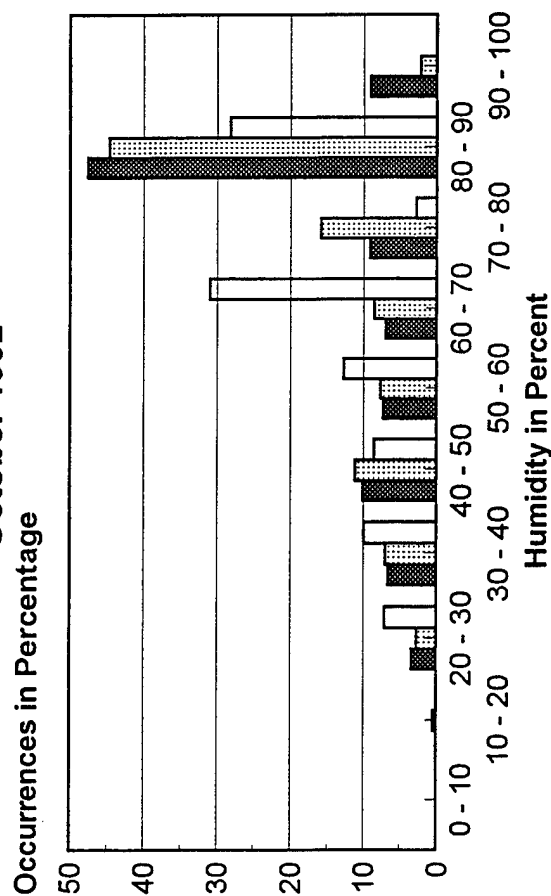
Humidity Histogram for Pallet #28



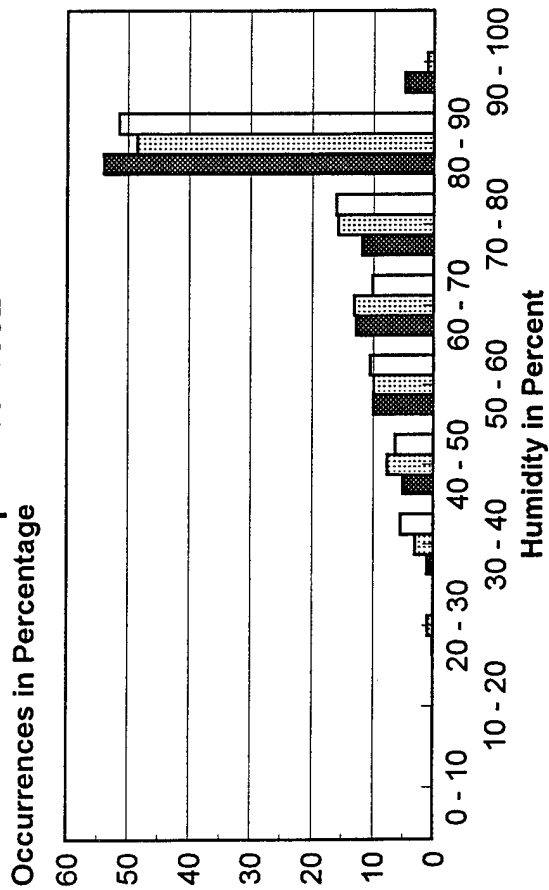
August 1992



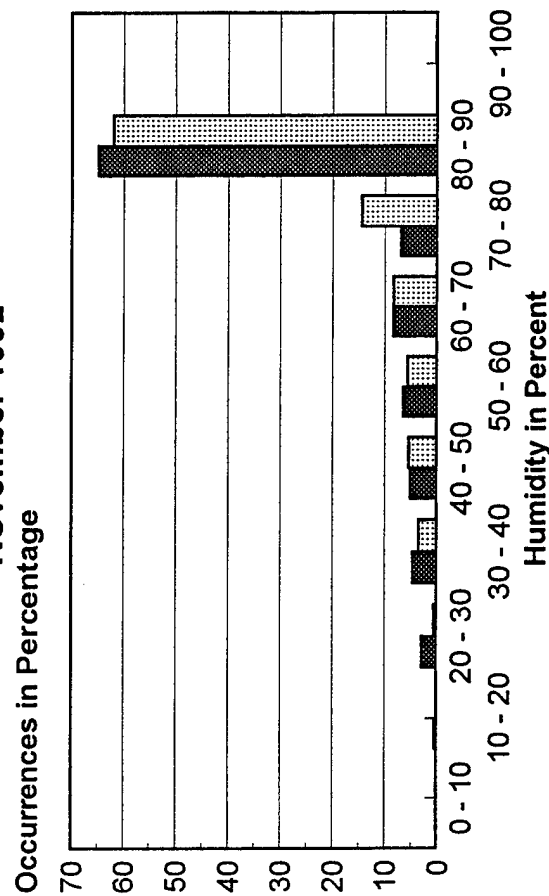
October 1992



September 1992

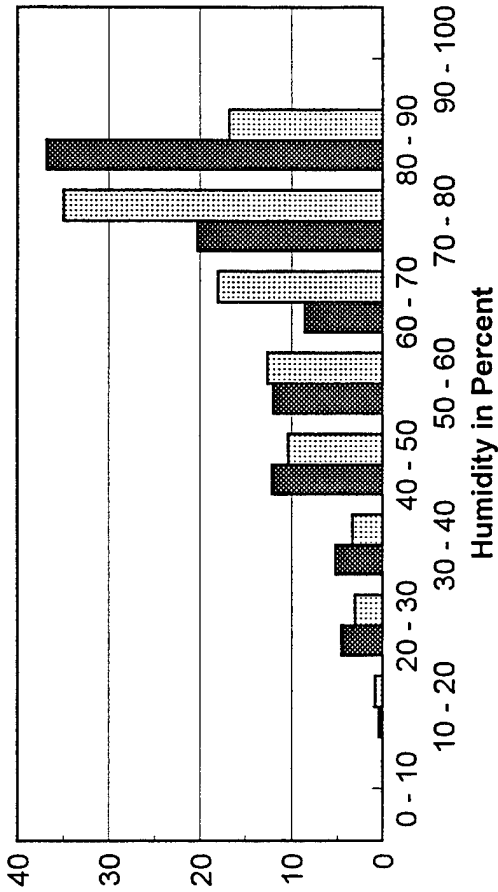


November 1992

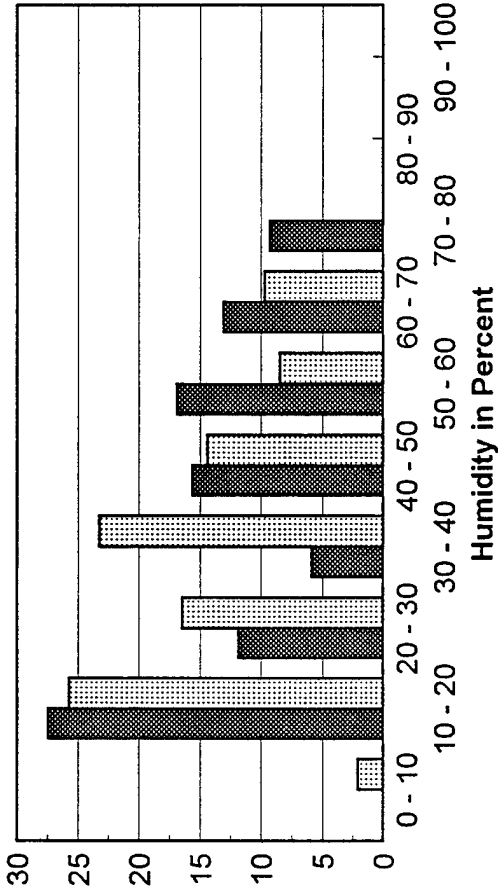


Humidity Histogram for Pallet #28

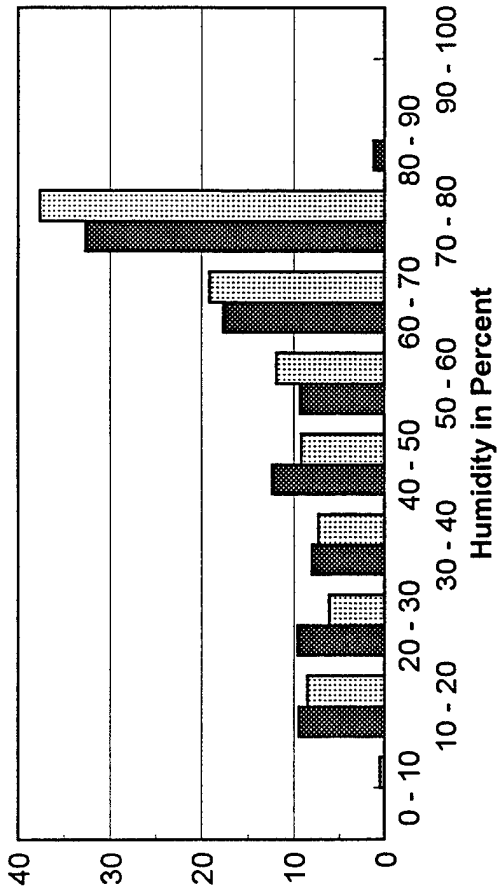
December 1992



February 1993

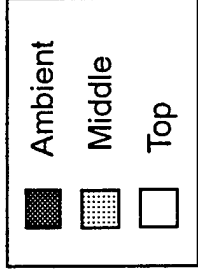


January 1993

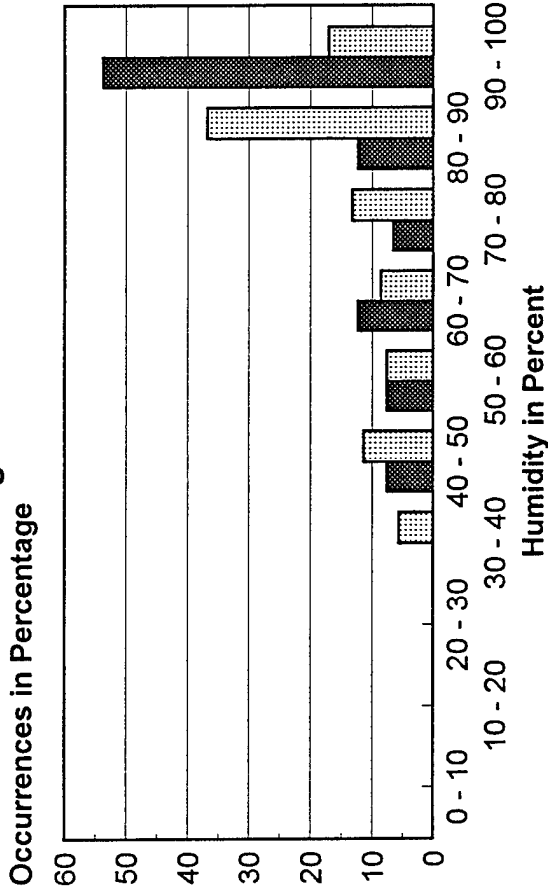


Ambient
Middle
Top

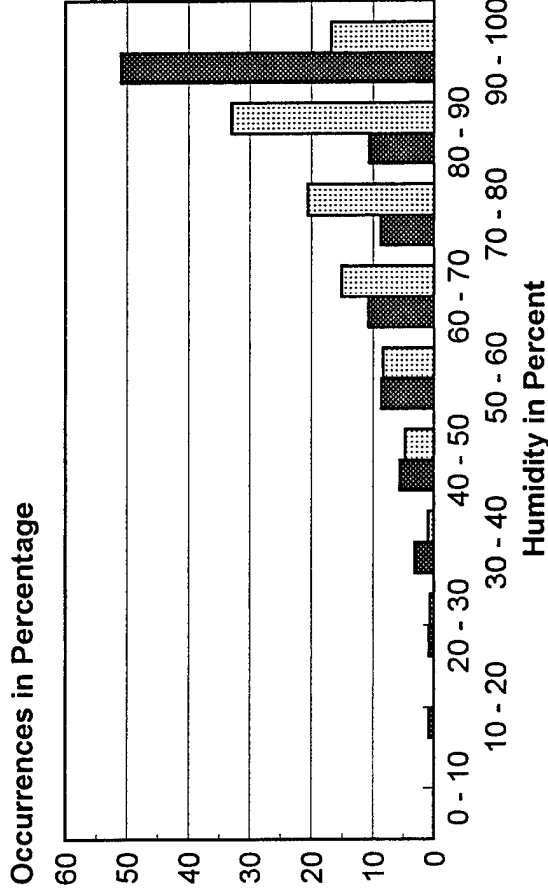
Humidity Histogram for Pallet #2



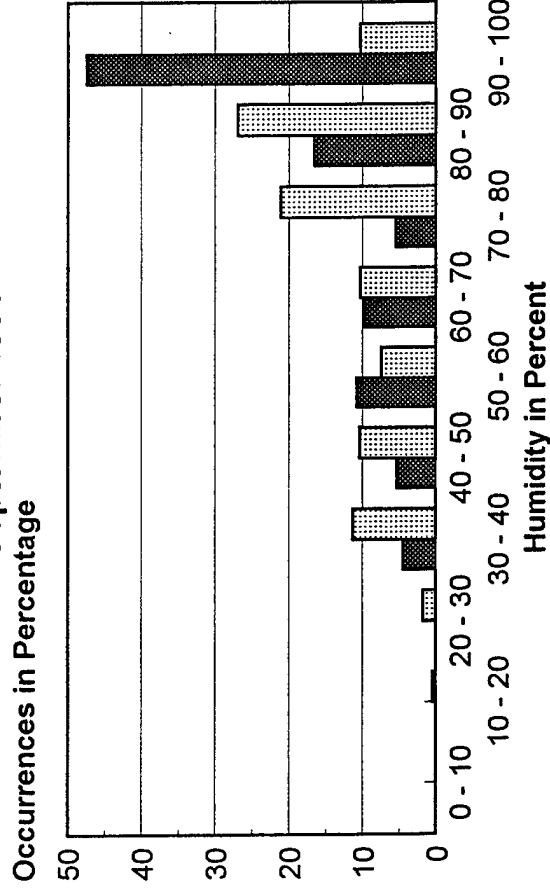
August 1991



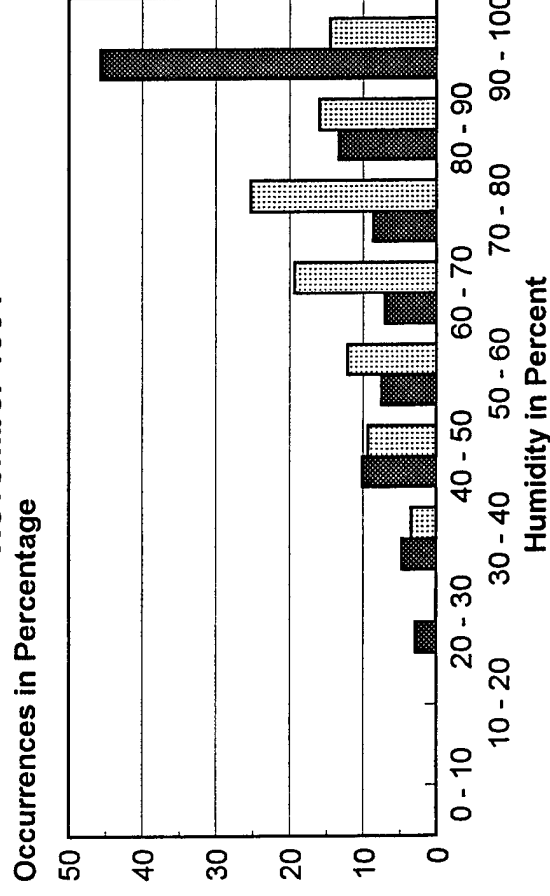
October 1991



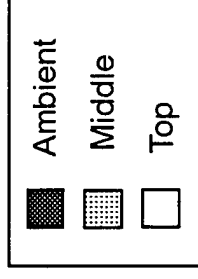
September 1991



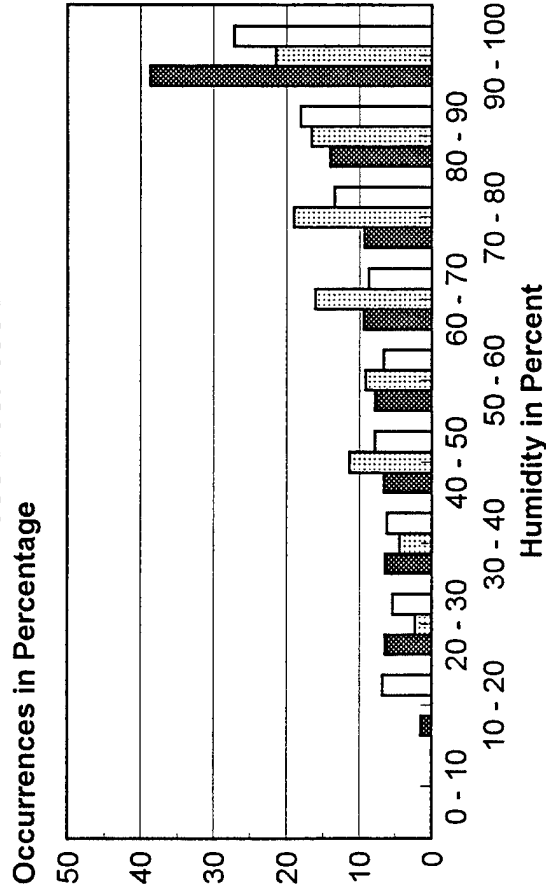
November 1991



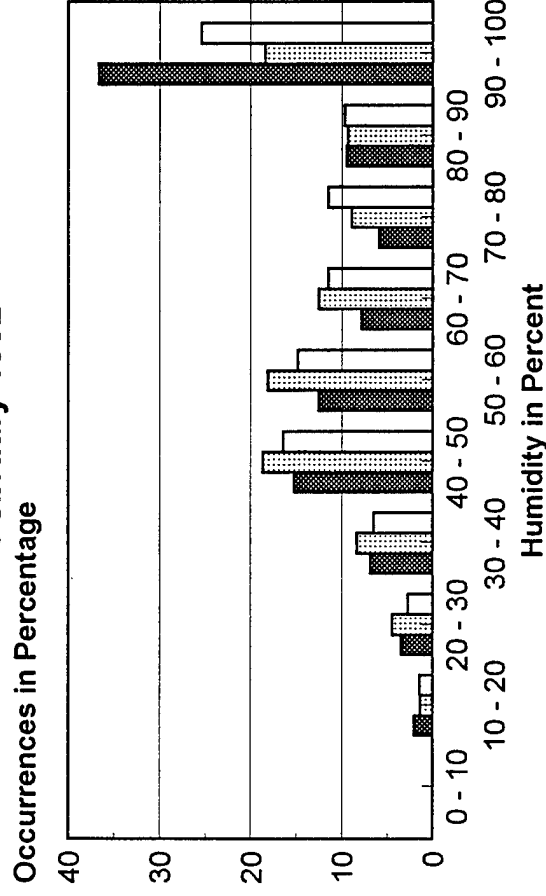
Humidity Histogram for Pallet #2



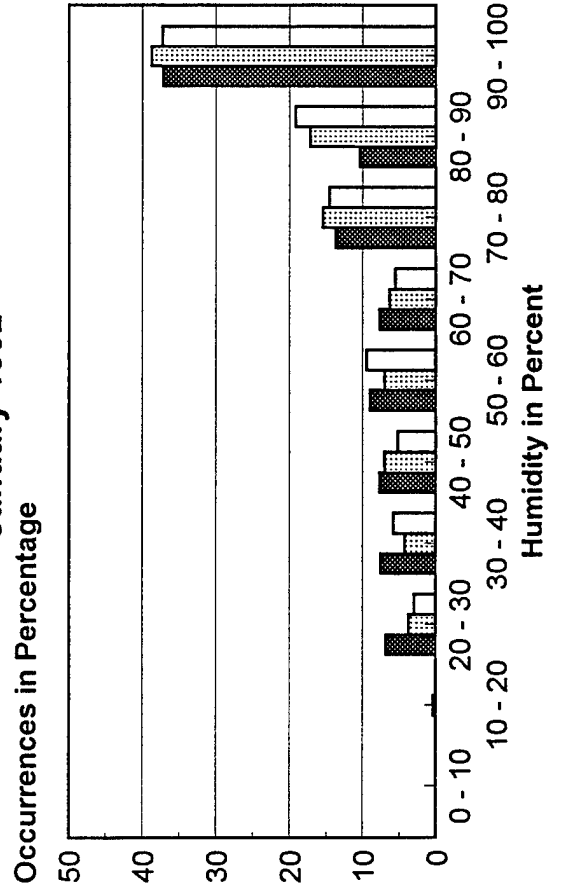
December 1991



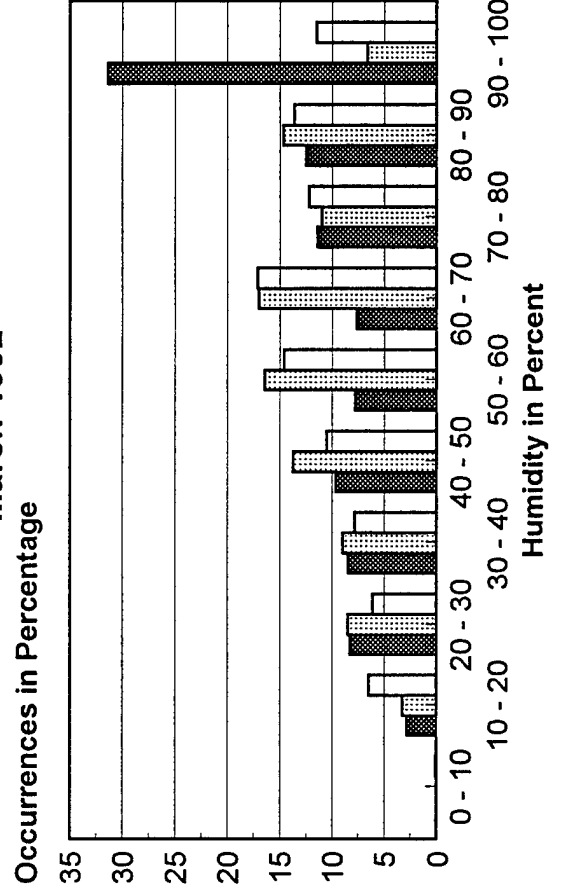
February 1992



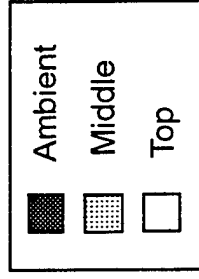
January 1992



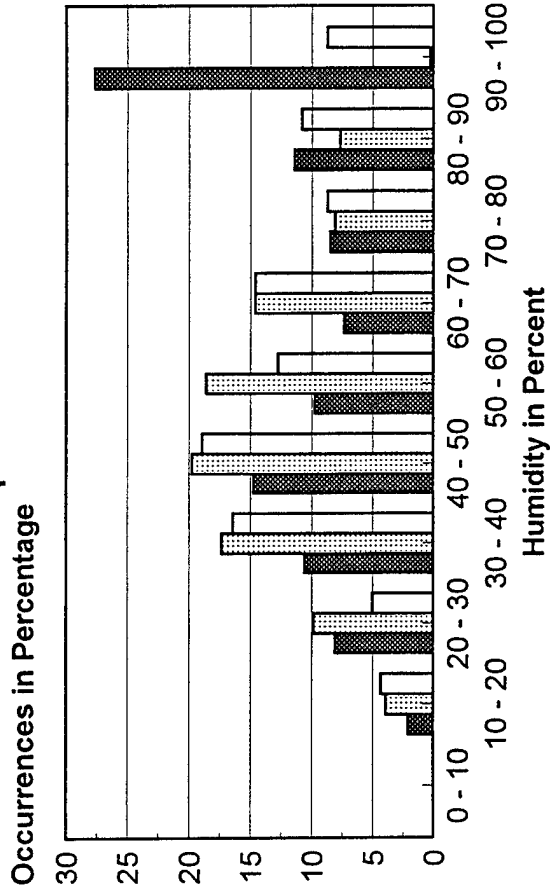
March 1992



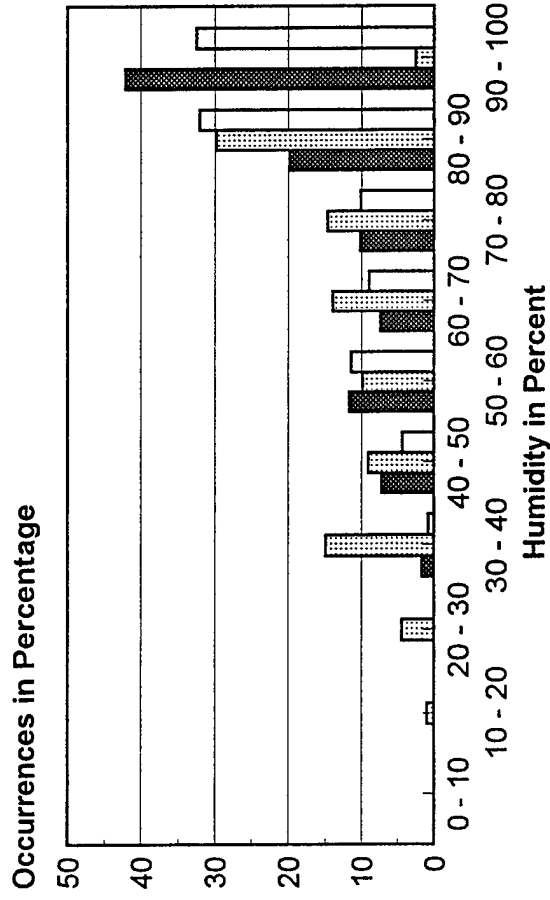
Humidity Histogram for Pallet #2



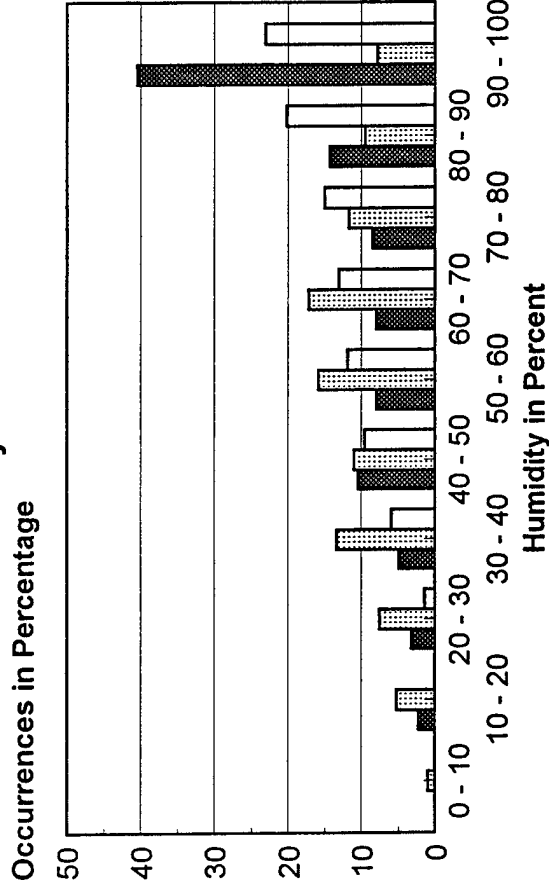
April 1992



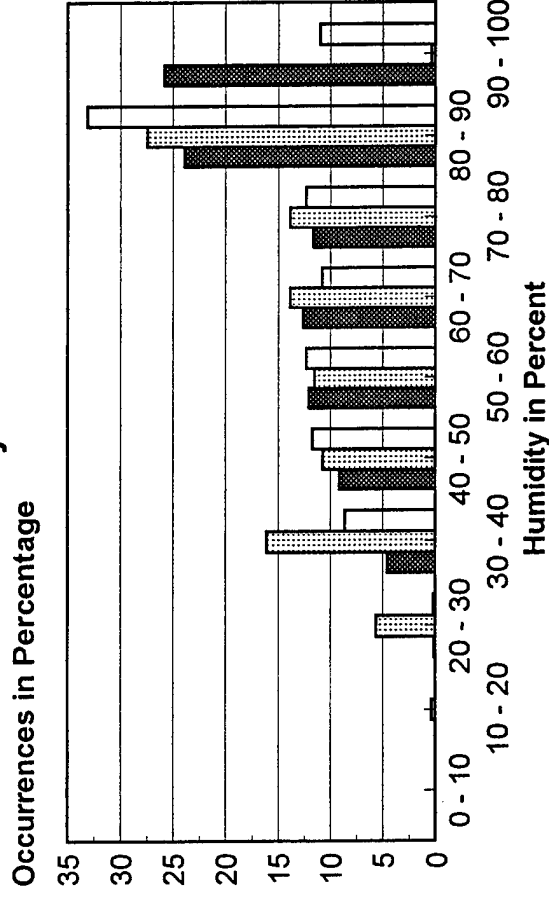
June 1992



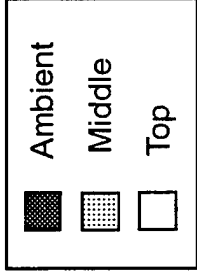
May 1992



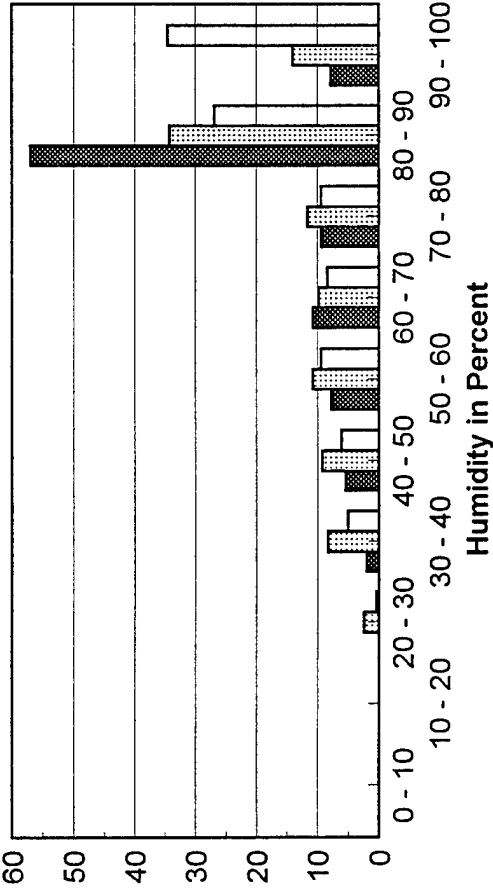
July 1992



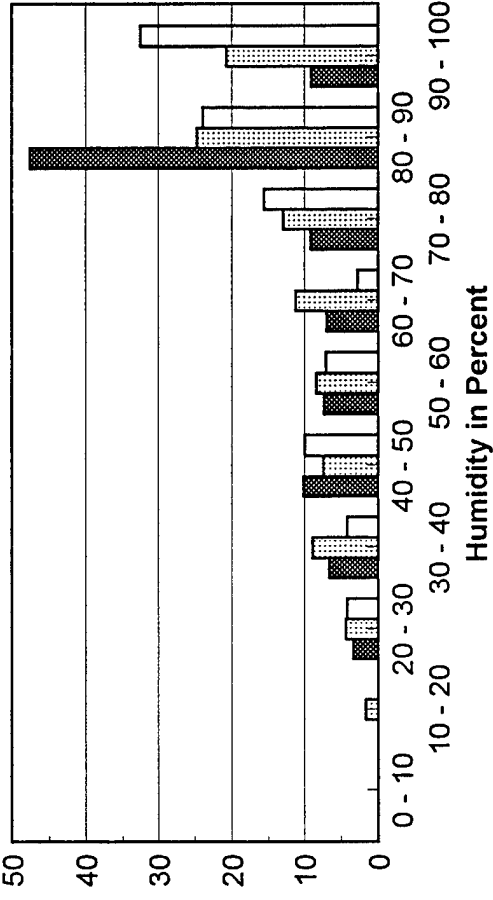
Humidity Histogram for Pallet #2



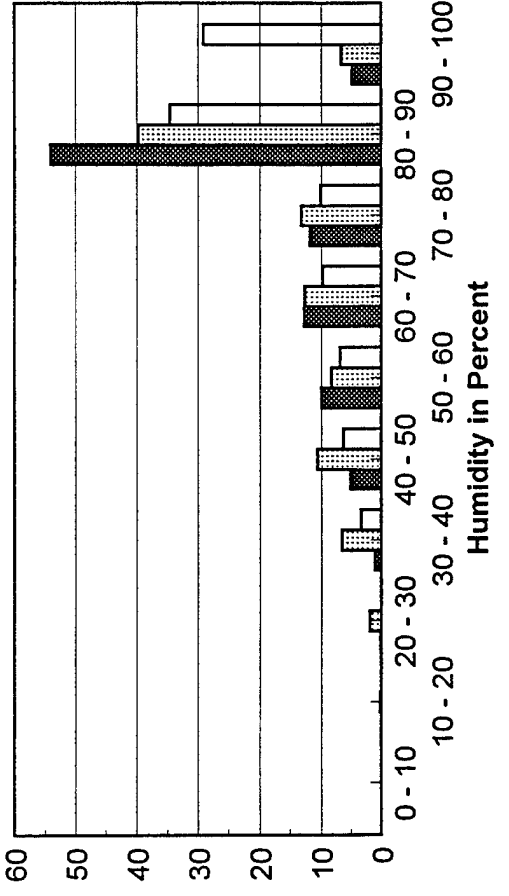
August 1992
Occurrences in Percentage



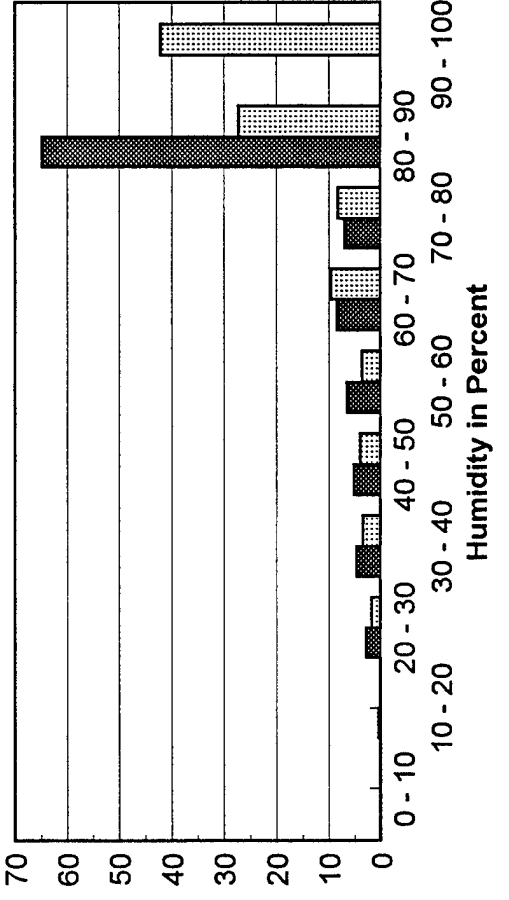
October 1992
Occurrences in Percentage



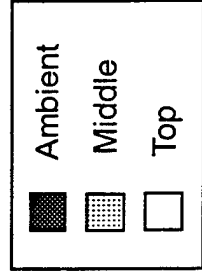
September 1992
Occurrences in Percentage



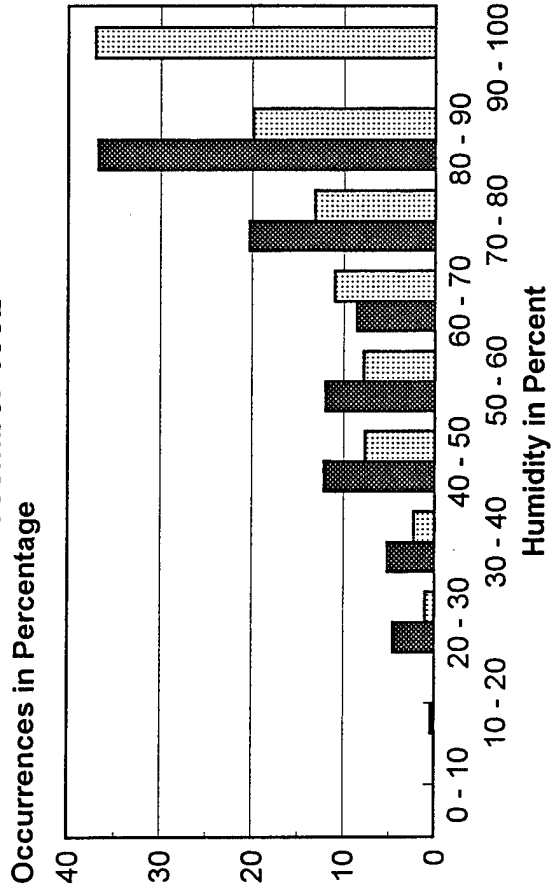
November 1992
Occurrences in Percentage



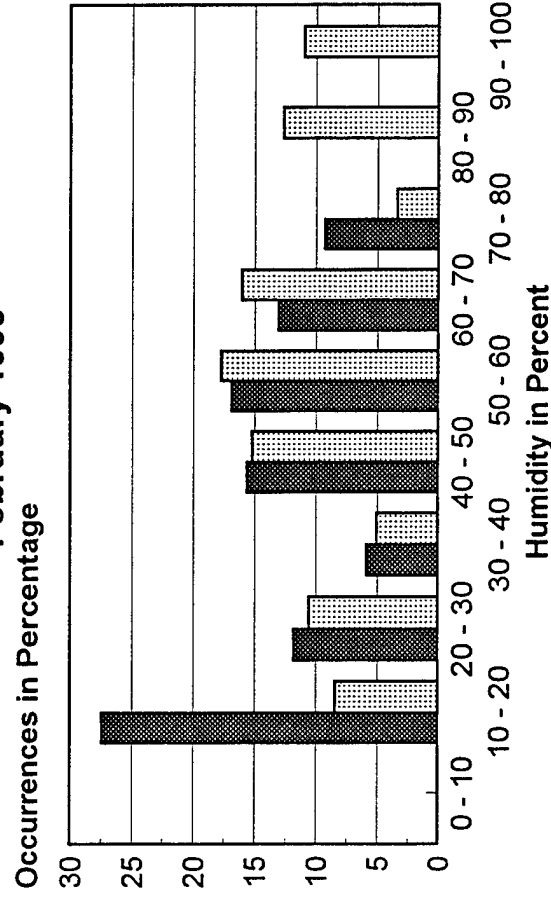
Humidity Histogram for Pallet #2



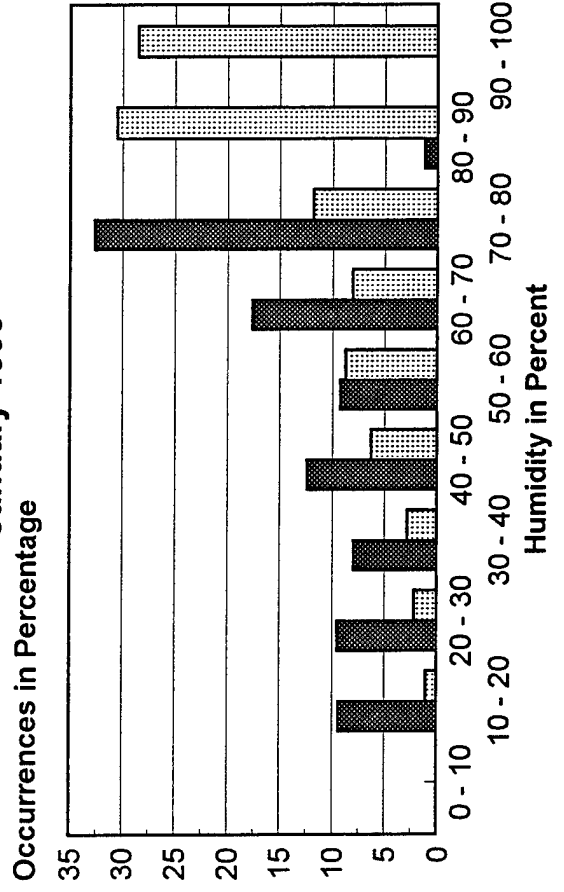
December 1992



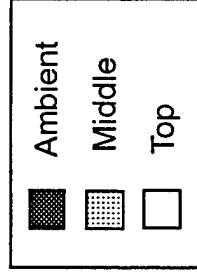
February 1993



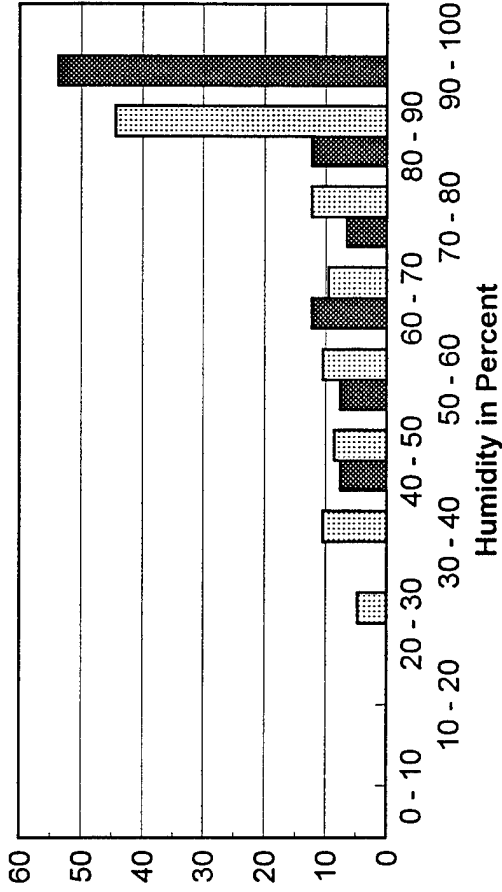
January 1993



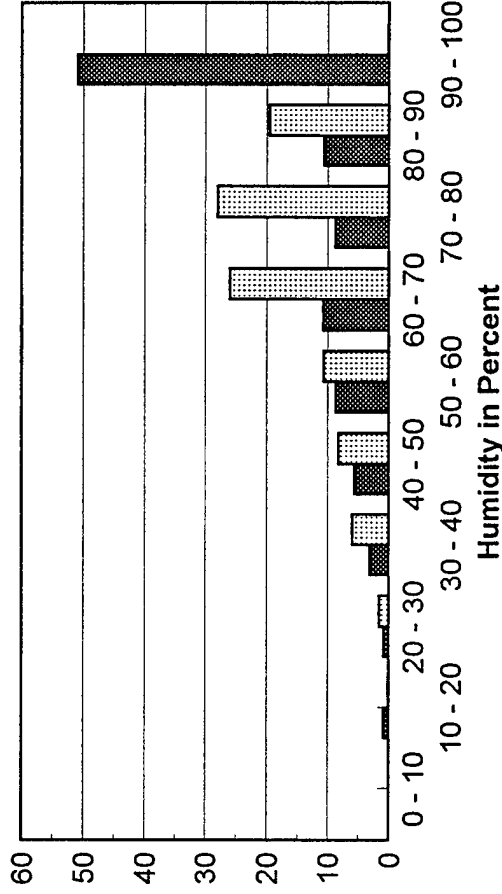
Humidity Histogram for Pallet #4



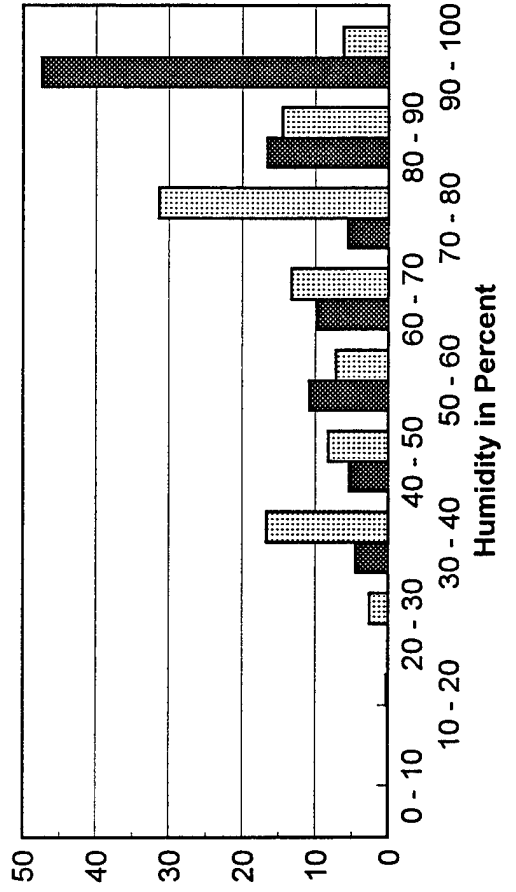
August 1991
Occurrences in Percentage



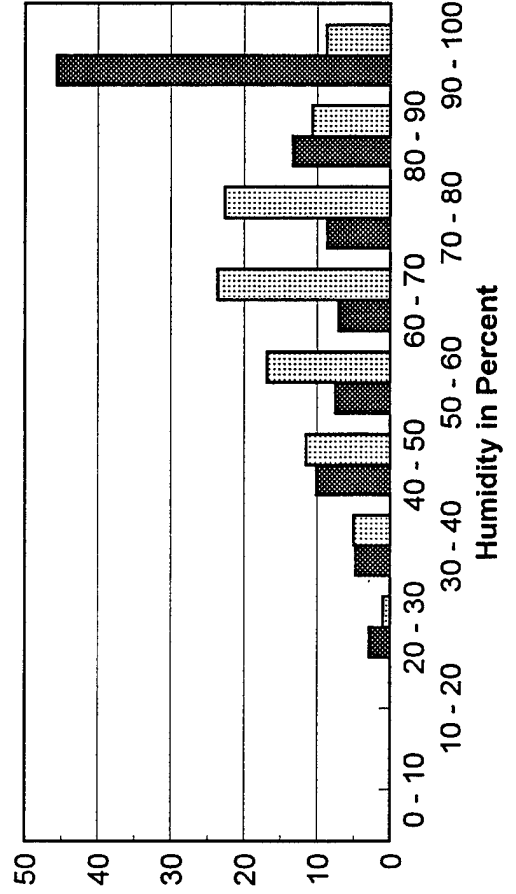
October 1991
Occurrences in Percentage



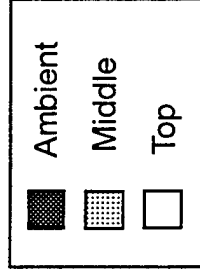
September 1991
Occurrences in Percentage



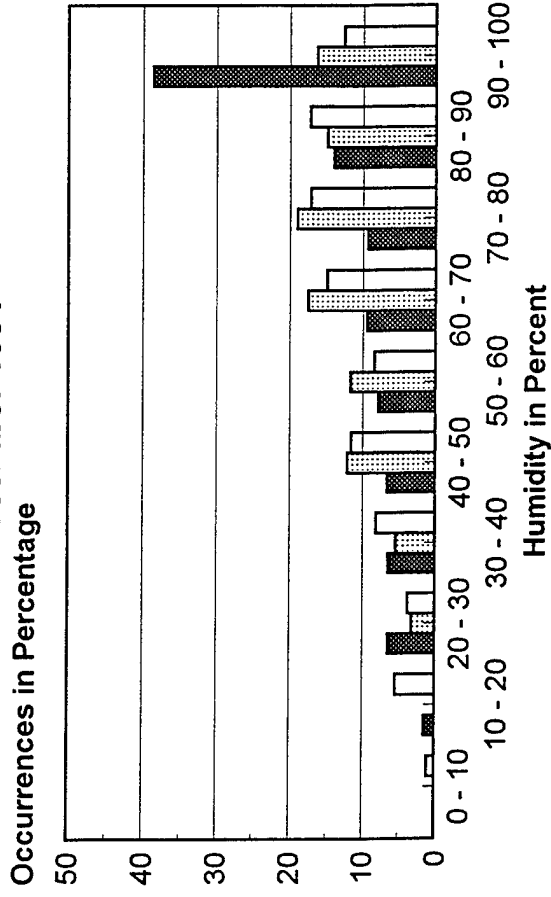
November 1991
Occurrences in Percentage



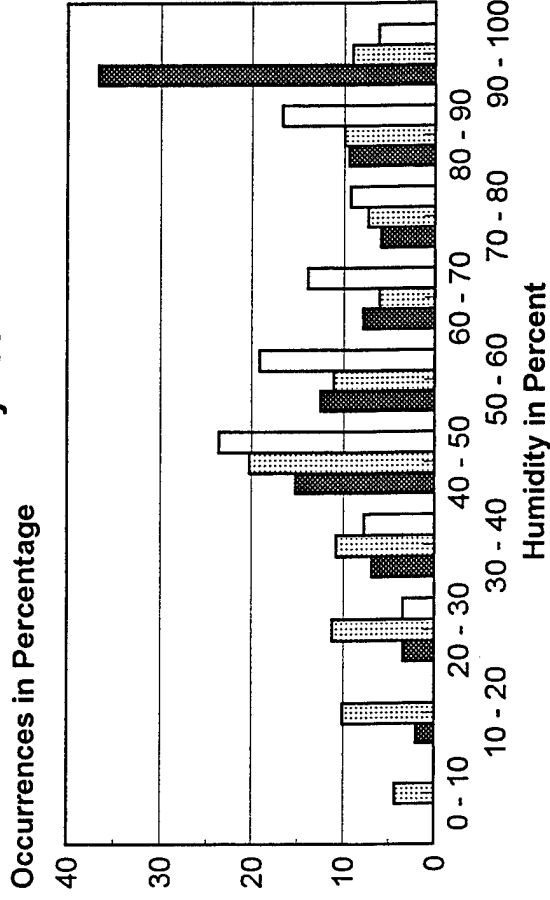
Humidity Histogram for Pallet #4



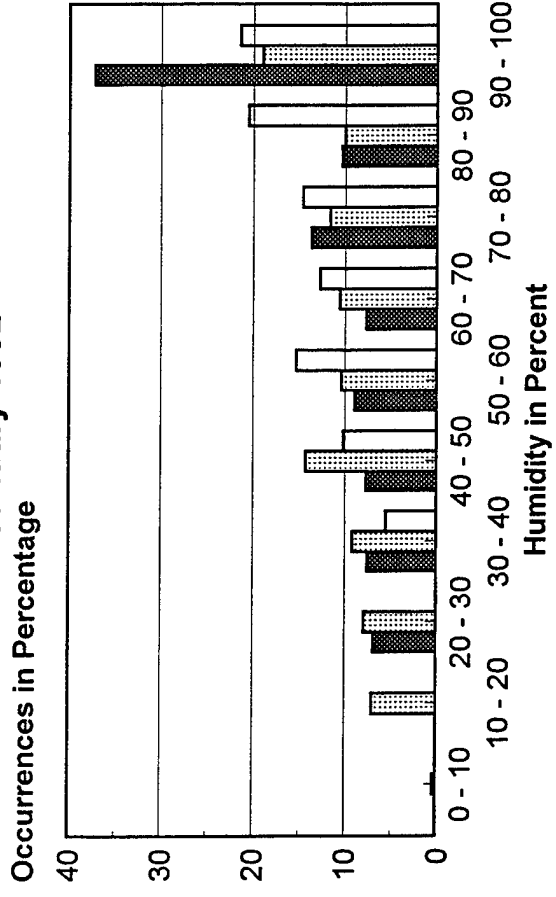
December 1991



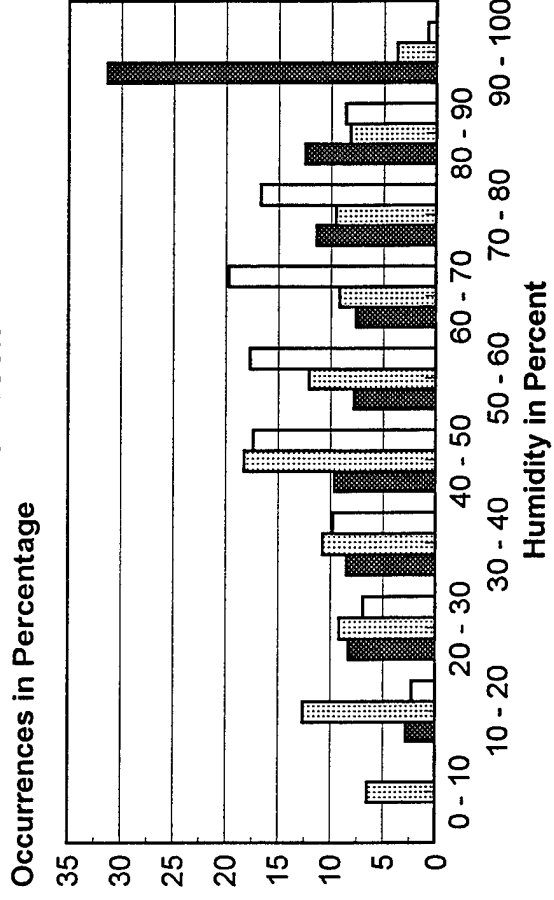
February 1992



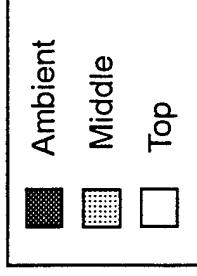
January 1992



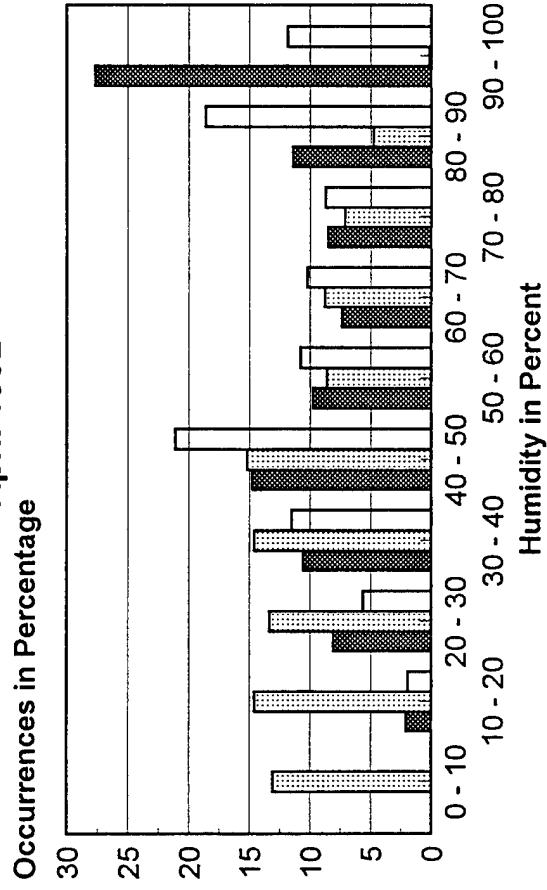
March 1992



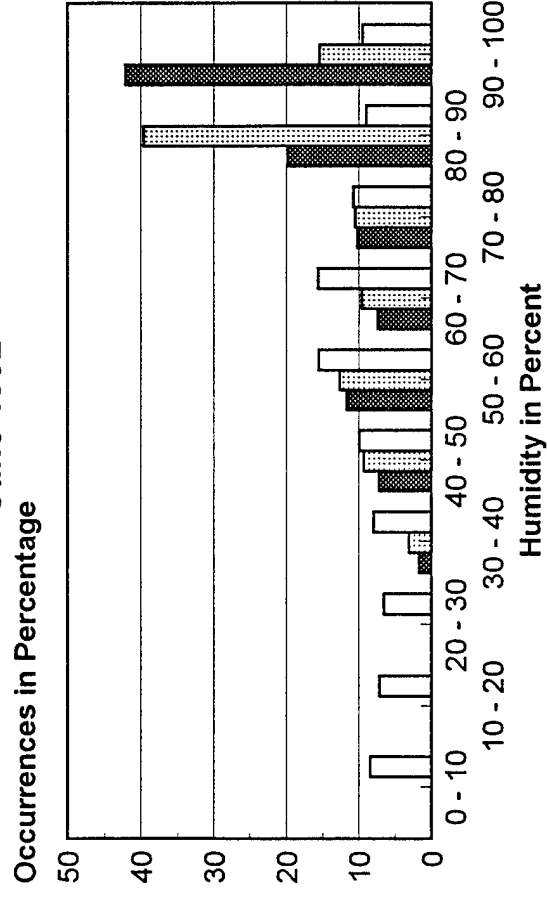
Humidity Histogram for Pallet #4



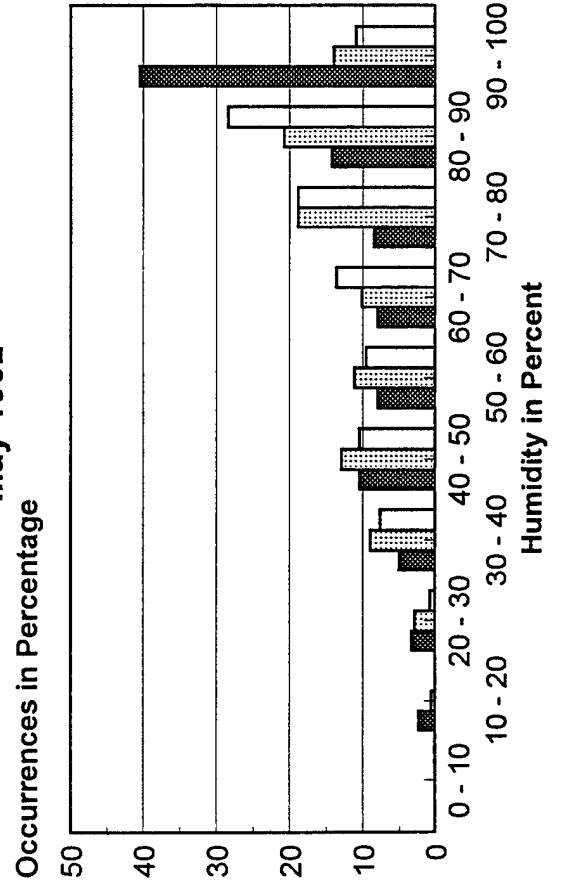
April 1992



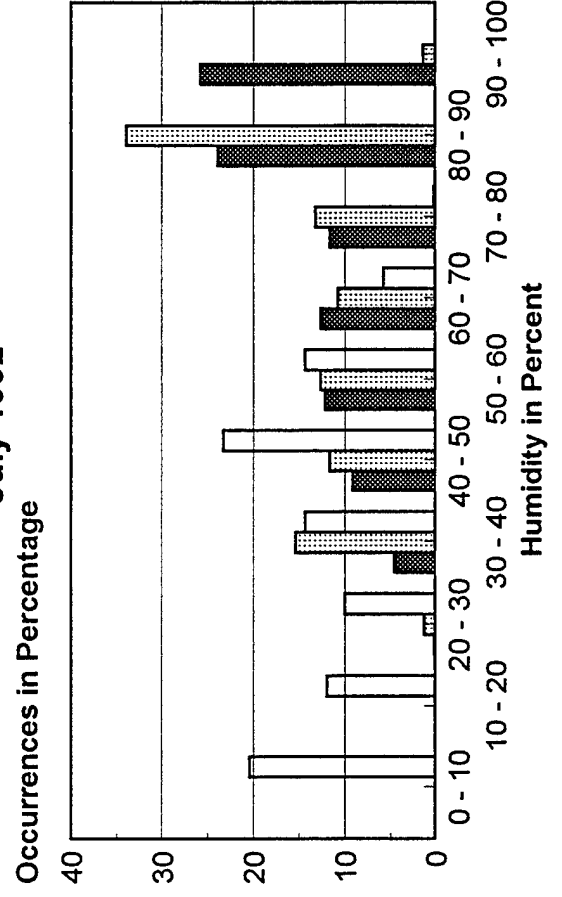
June 1992



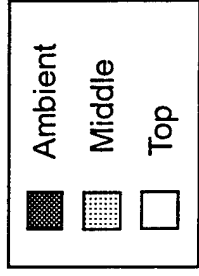
May 1992



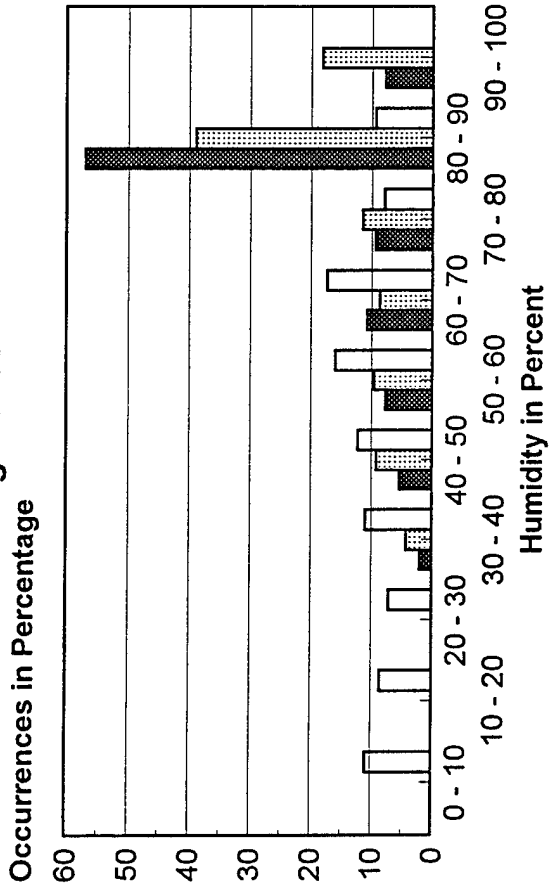
July 1992



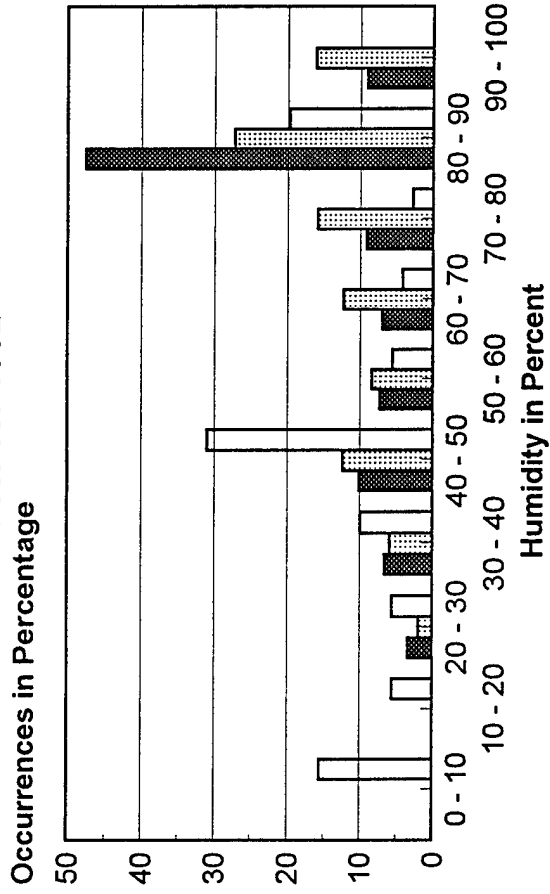
Humidity Histogram for Pallet #4



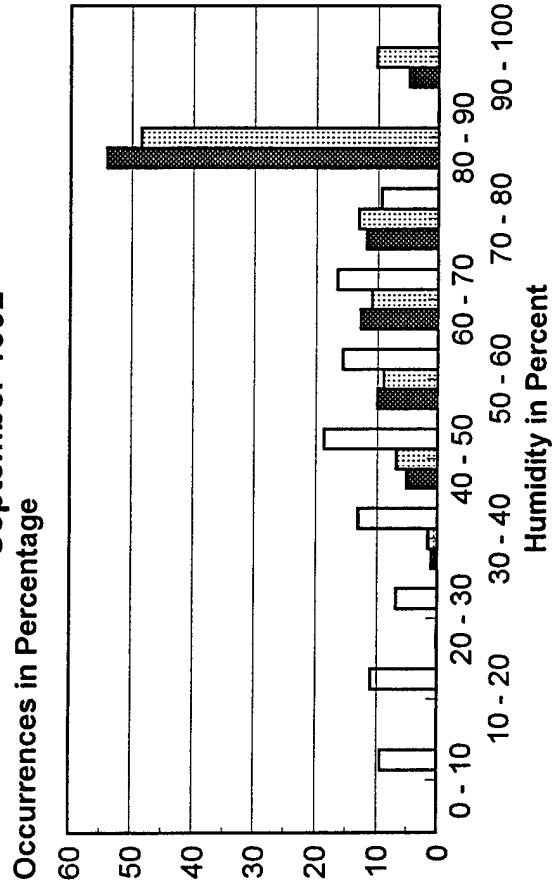
August 1992



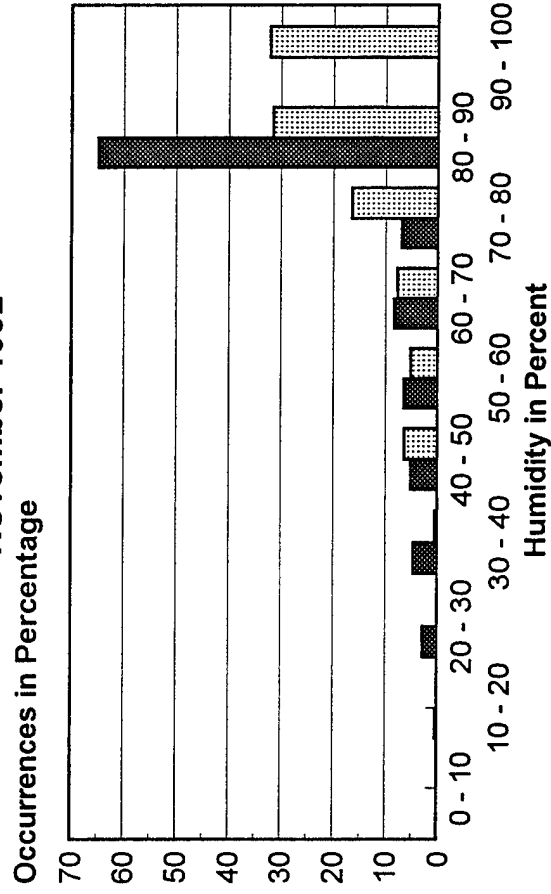
October 1992



September 1992

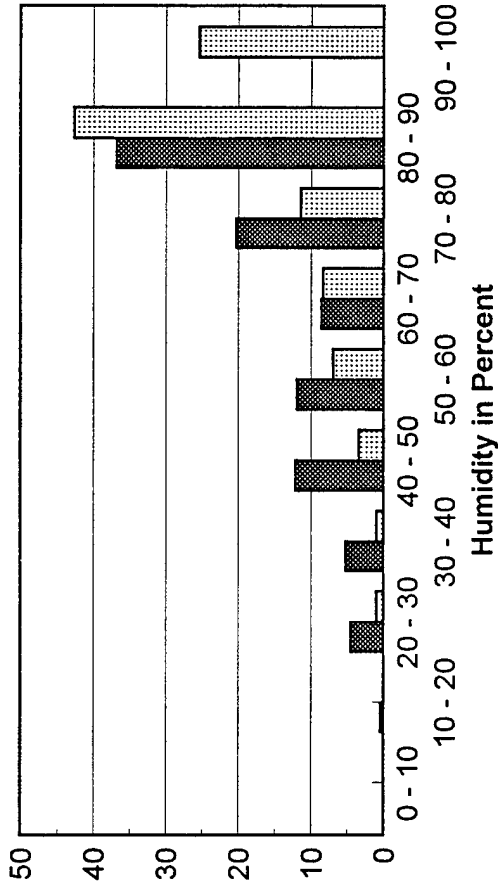


November 1992

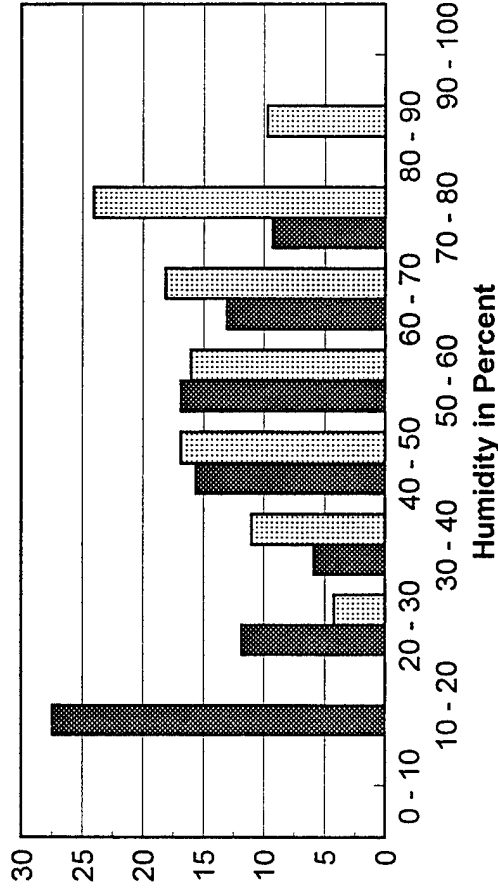


Humidity Histogram for Pallet #4

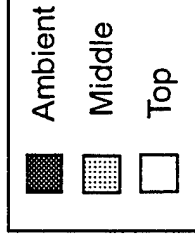
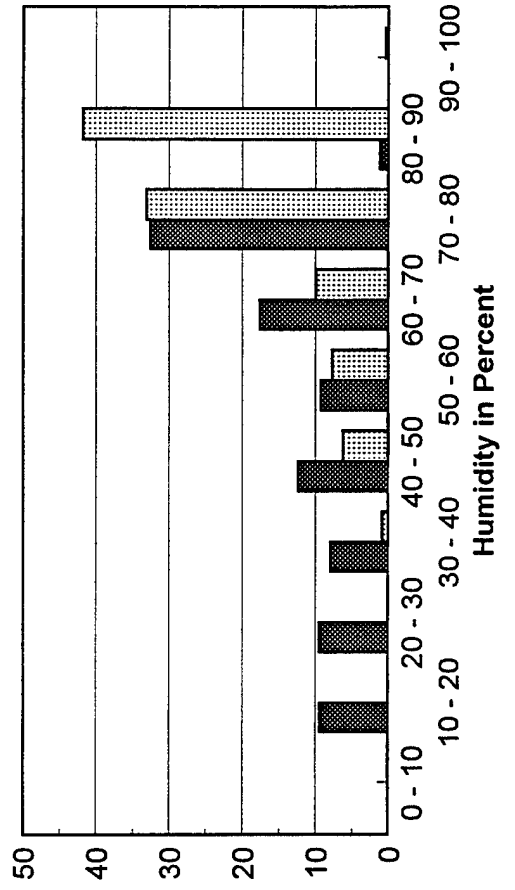
December 1992



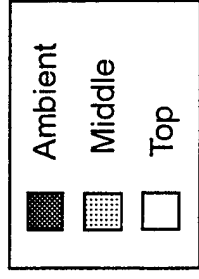
February 1993



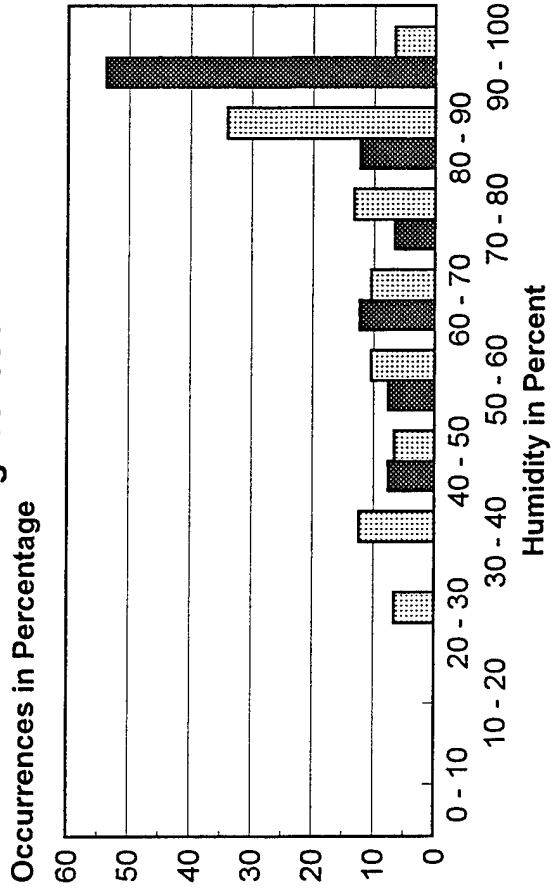
January 1993



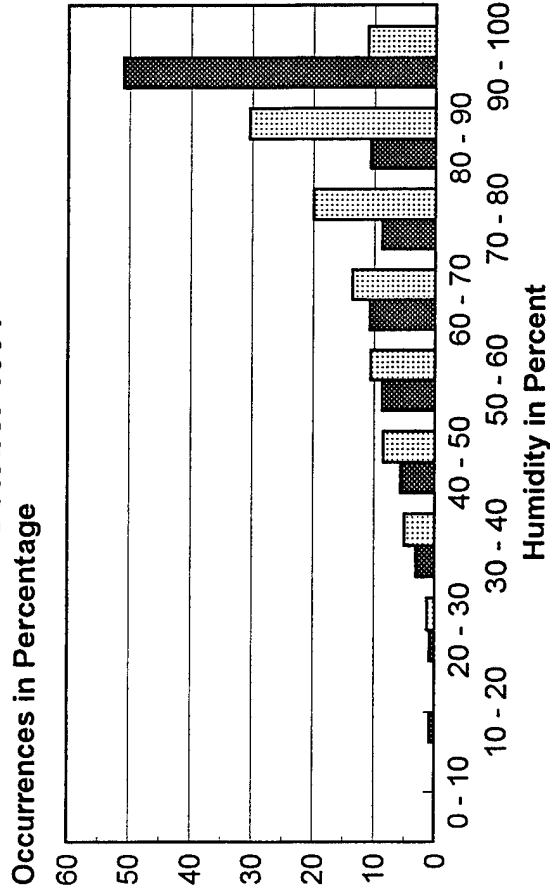
Humidity Histogram for Pallet #7



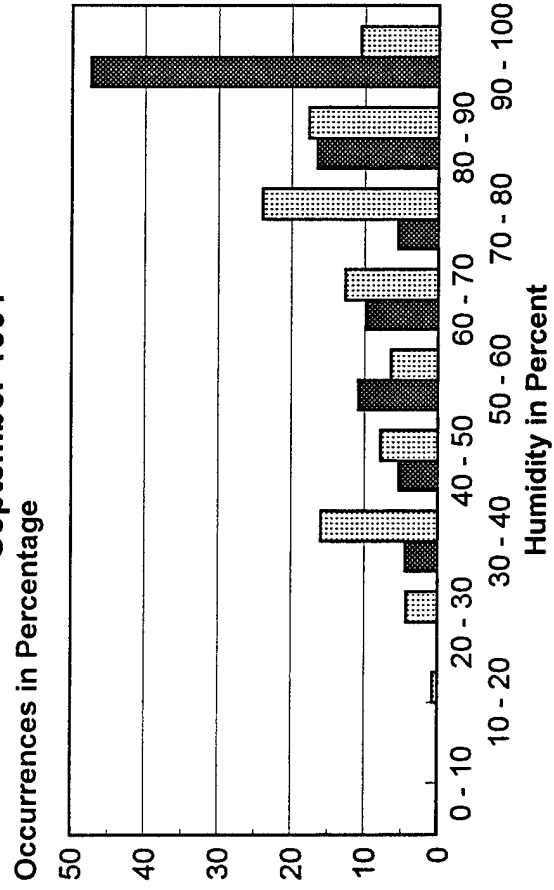
August 1991



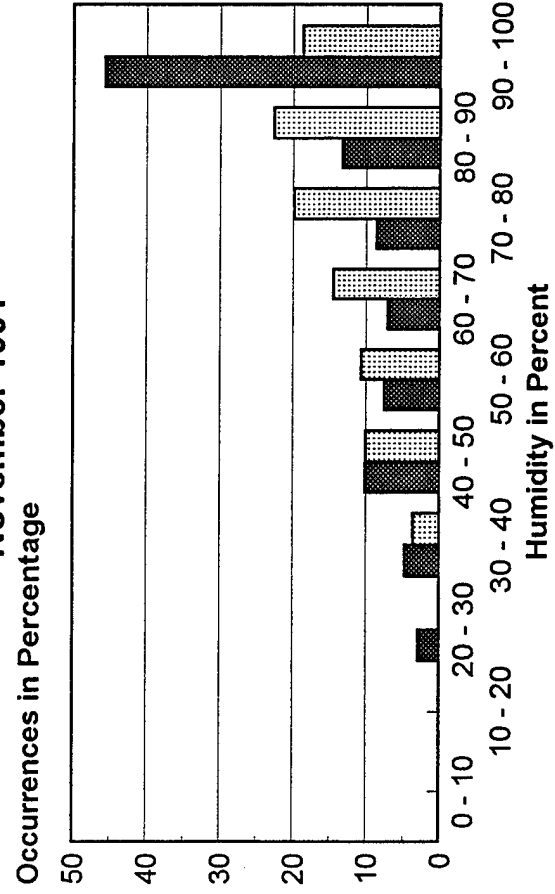
October 1991



September 1991

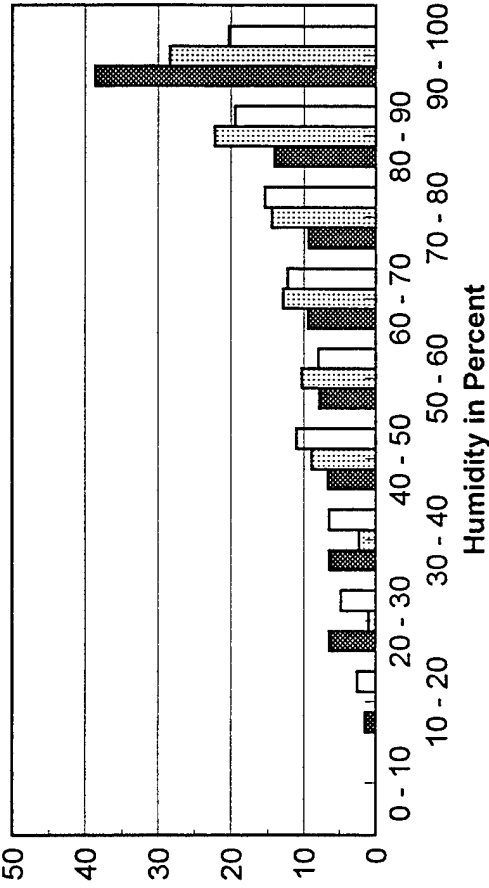


November 1991

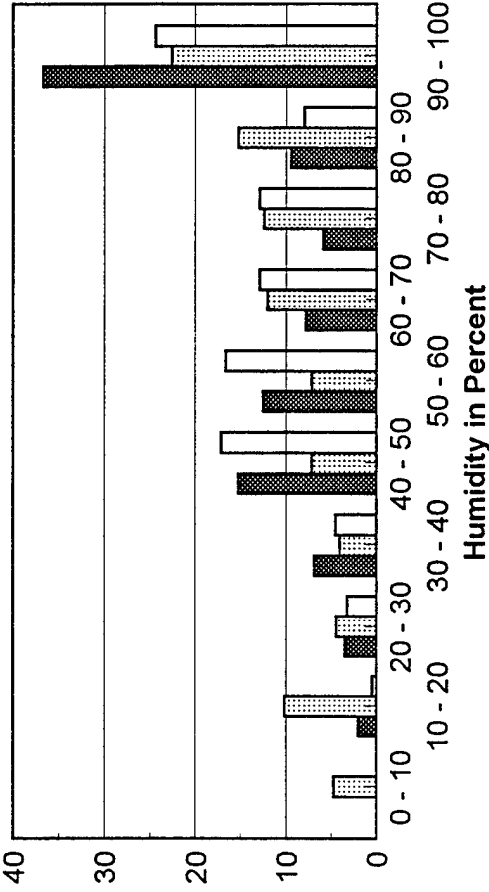


Humidity Histogram for Pallet #7

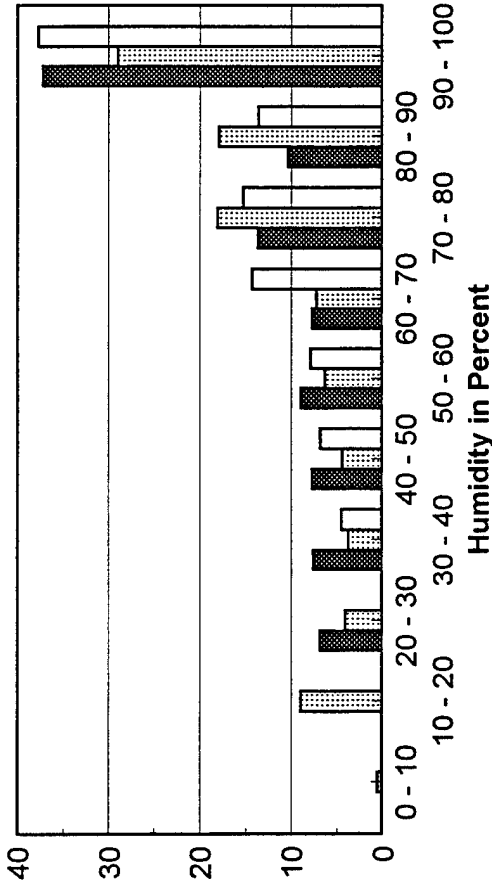
December 1991
Occurrences in Percentage



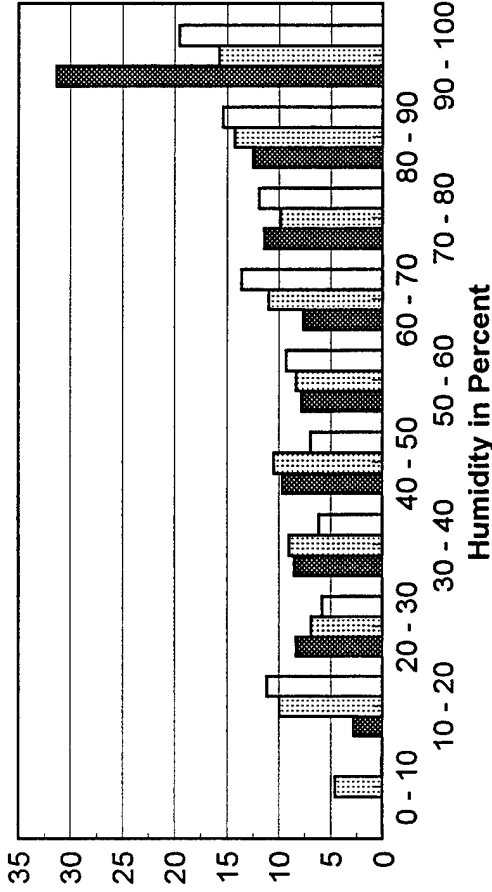
February 1992
Occurrences in Percentage



January 1992
Occurrences in Percentage

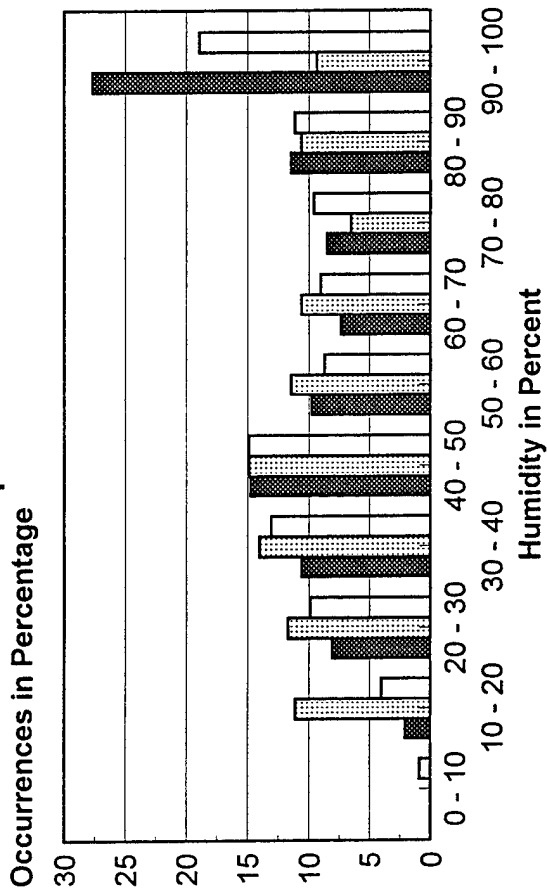


March 1992
Occurrences in Percentage

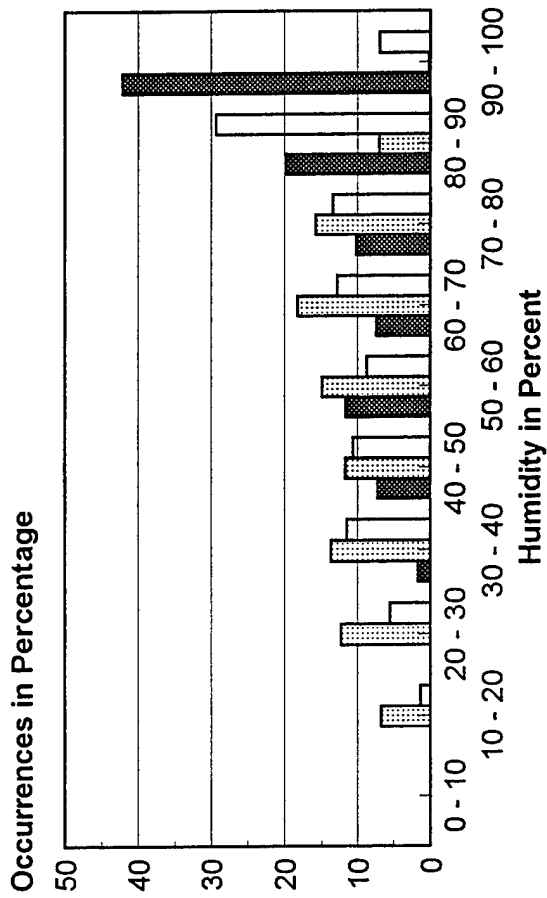


Humidity Histogram for Pallet #7

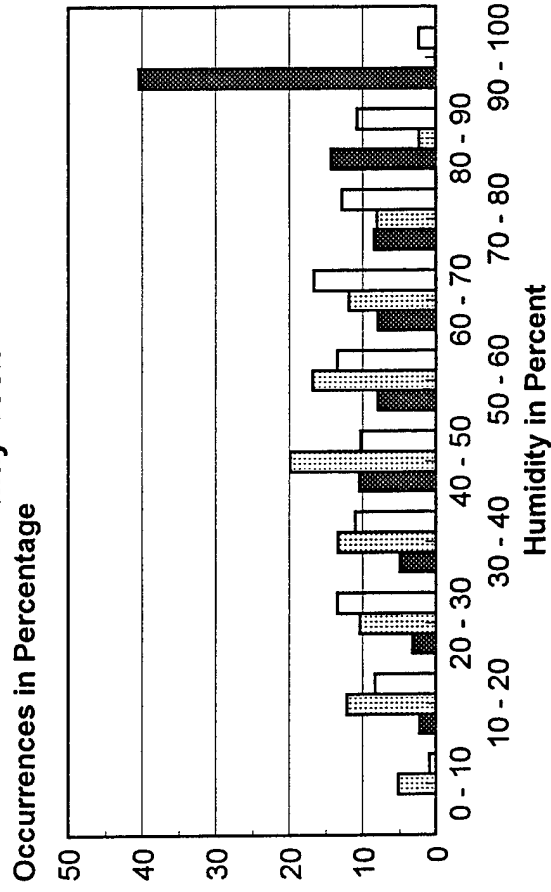
April 1992



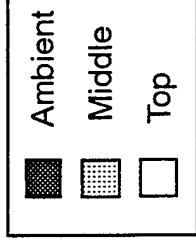
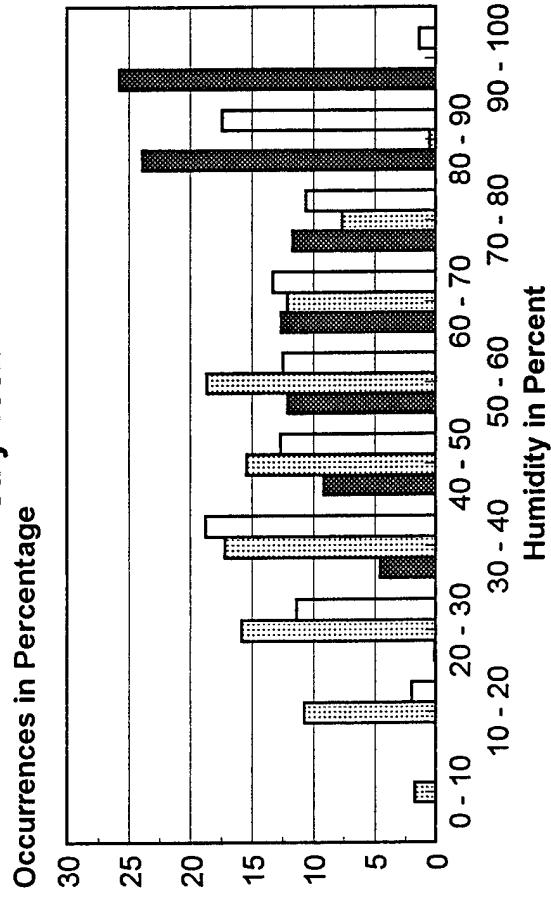
June 1992



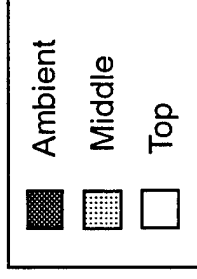
May 1992



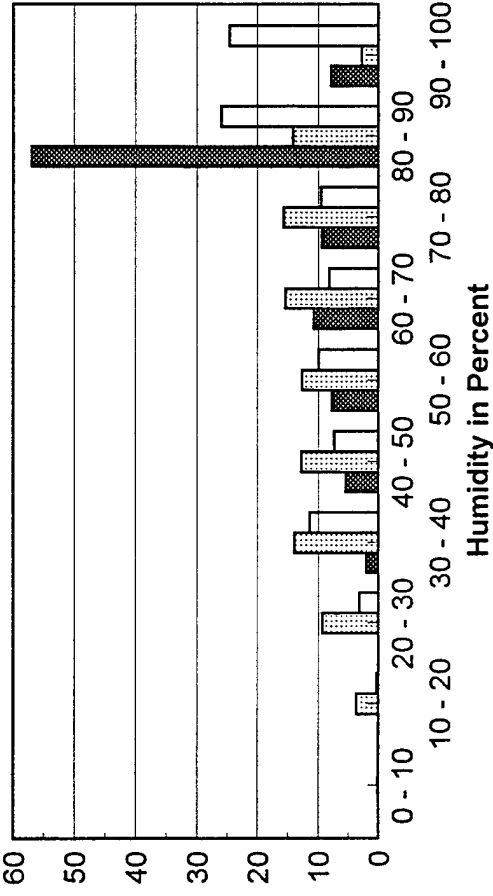
July 1992



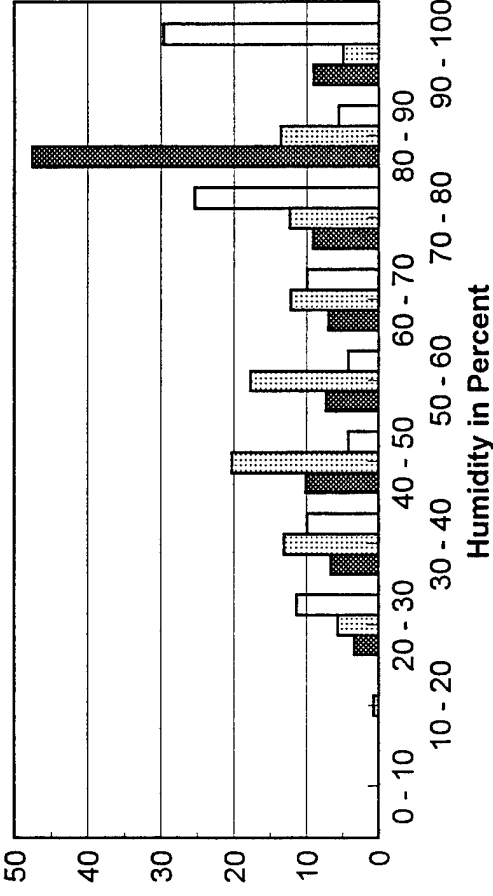
Humidity Histogram for Pallet #7



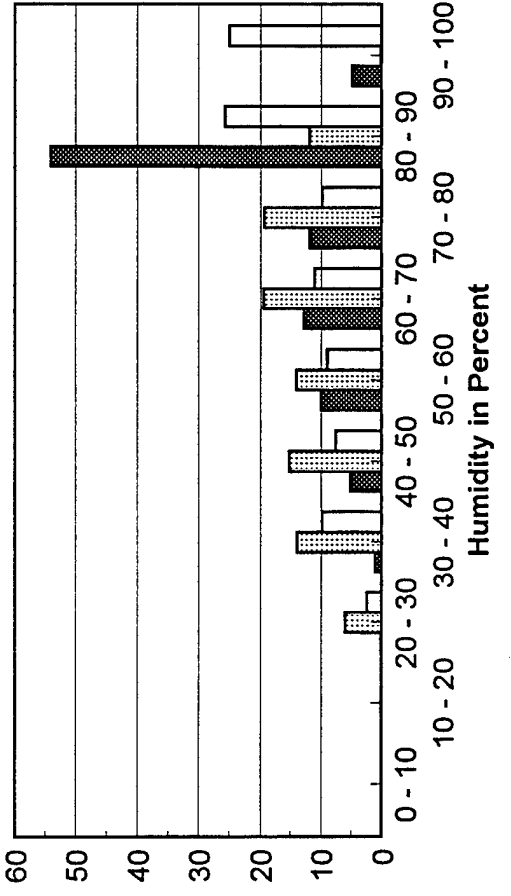
August 1992
Occurrences in Percentage



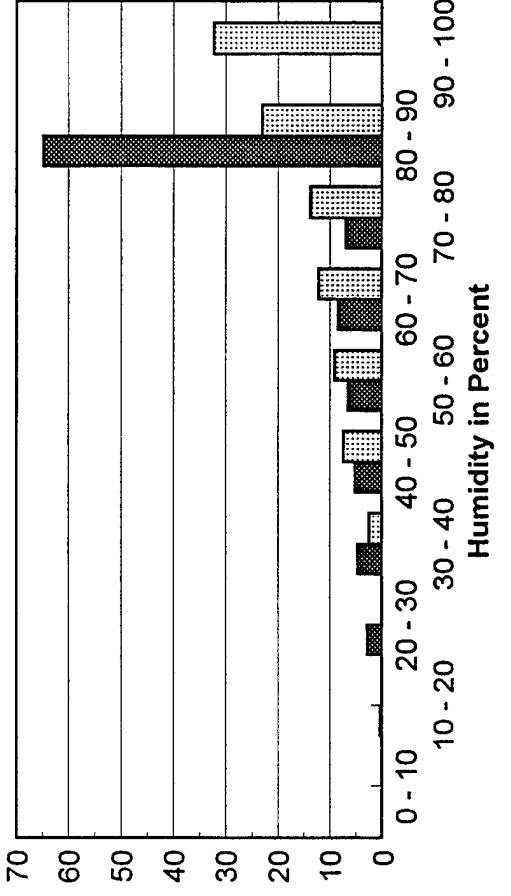
October 1992
Occurrences in Percentage



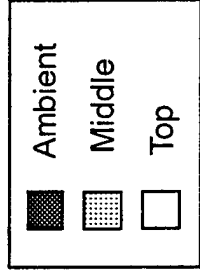
September 1992
Occurrences in Percentage



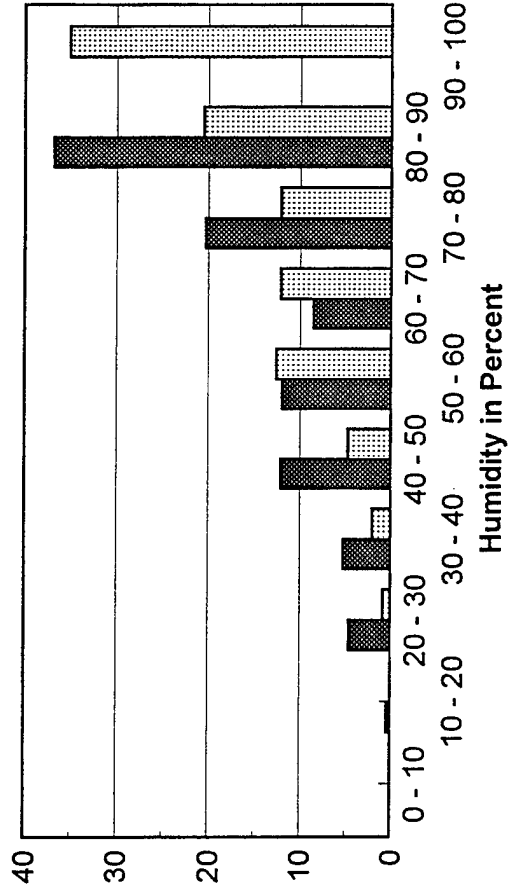
November 1992
Occurrences in Percentage



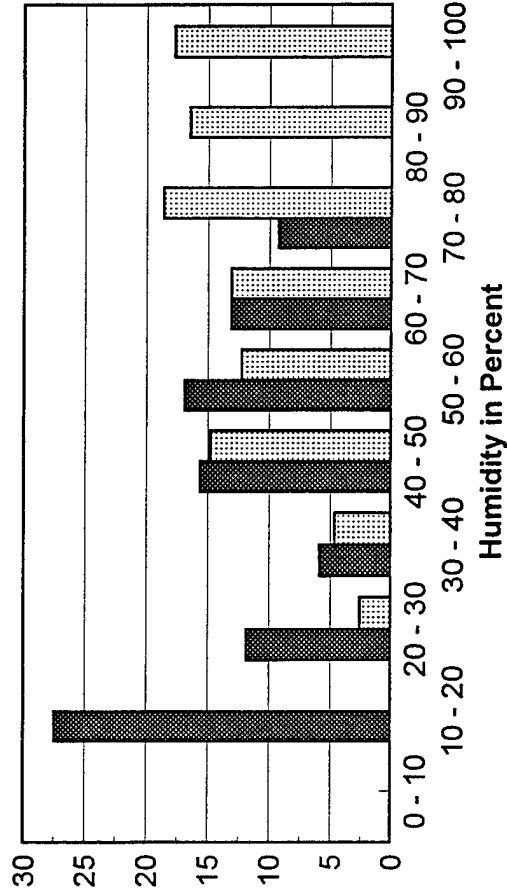
Humidity Histogram for Pallet #7



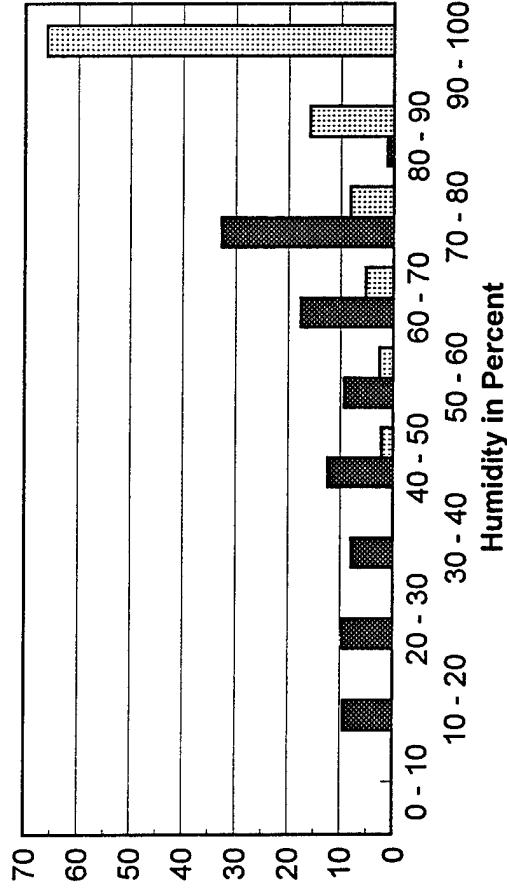
December 1992



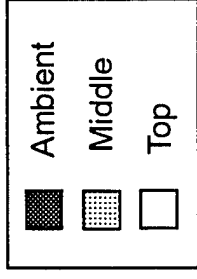
February 1993



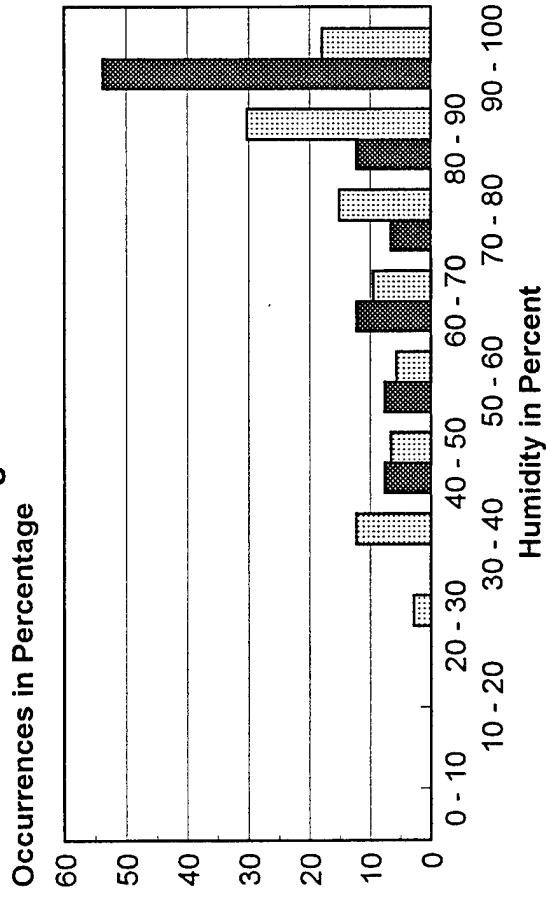
January 1993



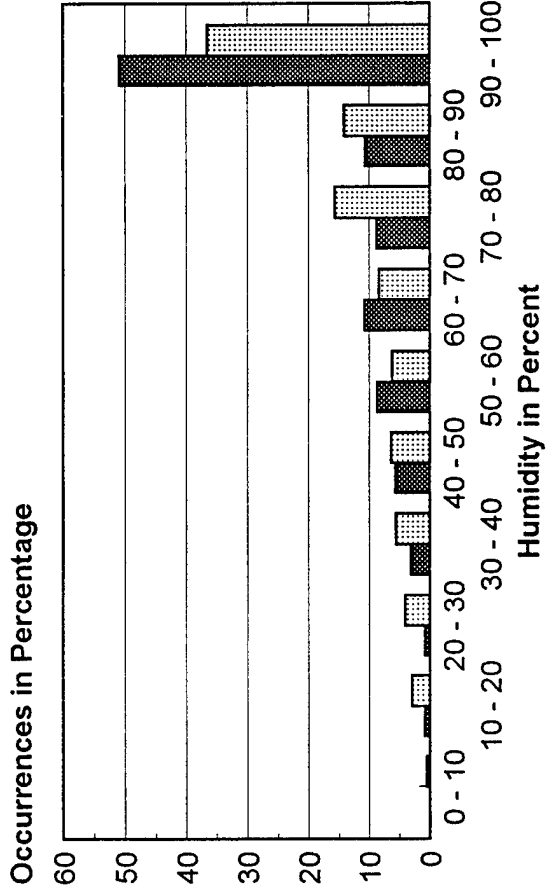
Humidity Histogram for Pallet #9



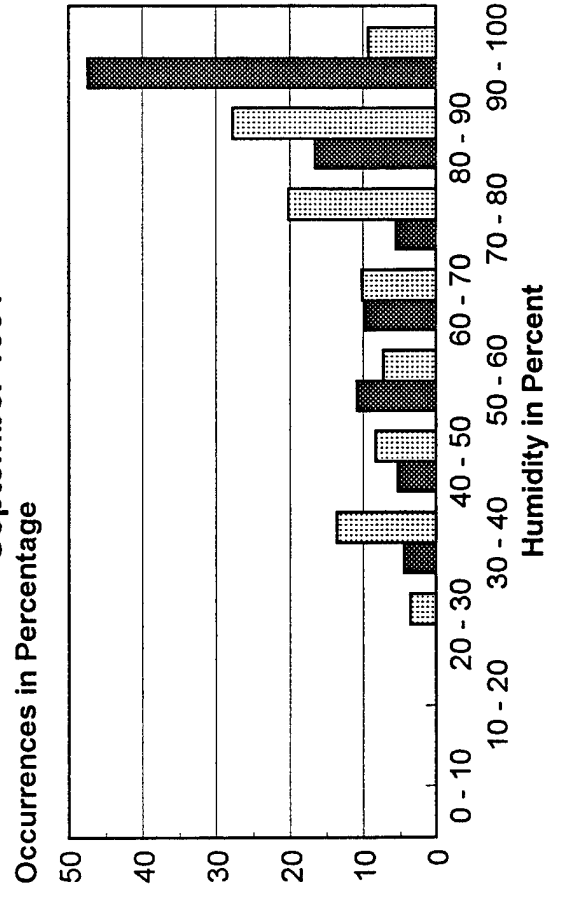
August 1991



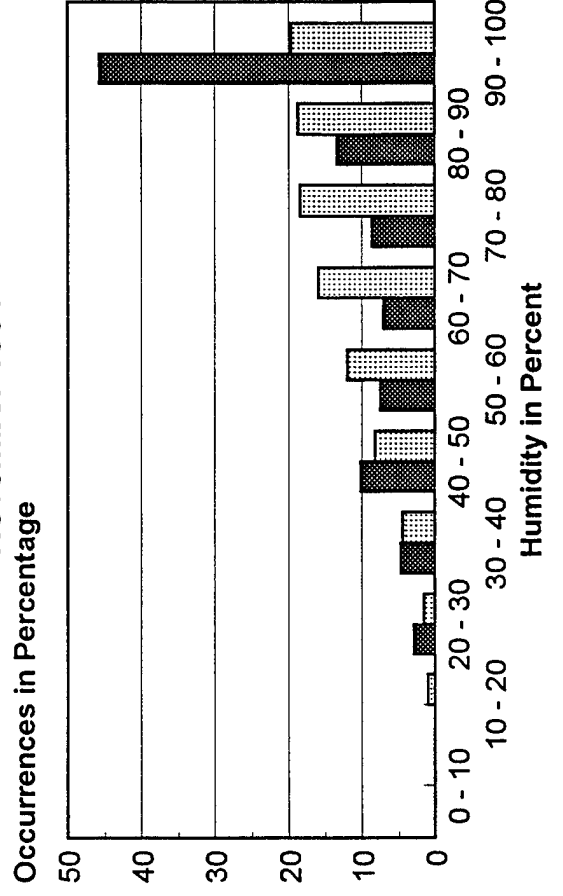
October 1991



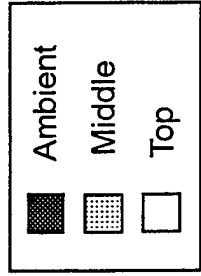
September 1991



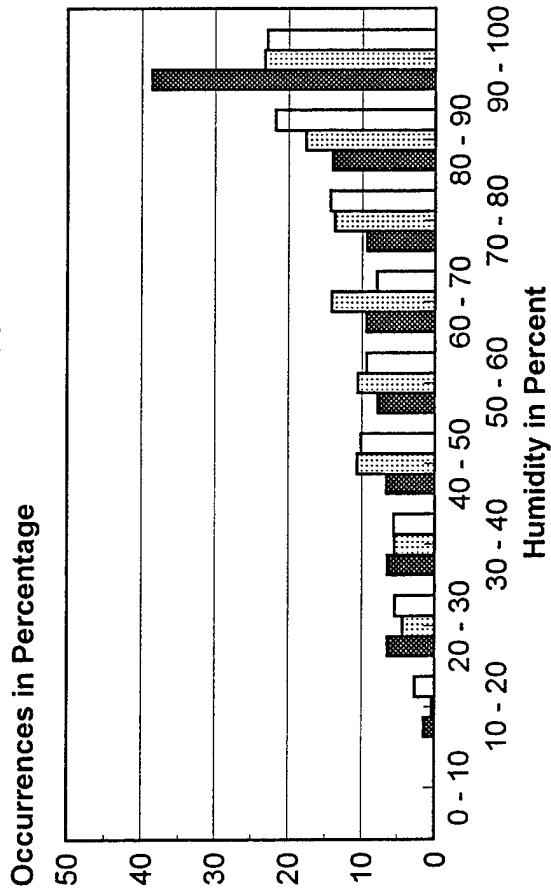
November 1991



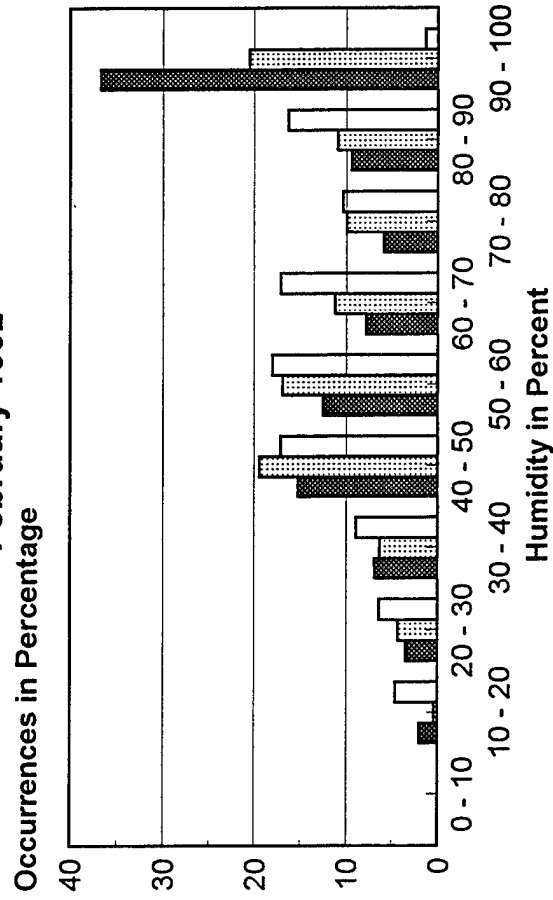
Humidity Histogram for Pallet #9



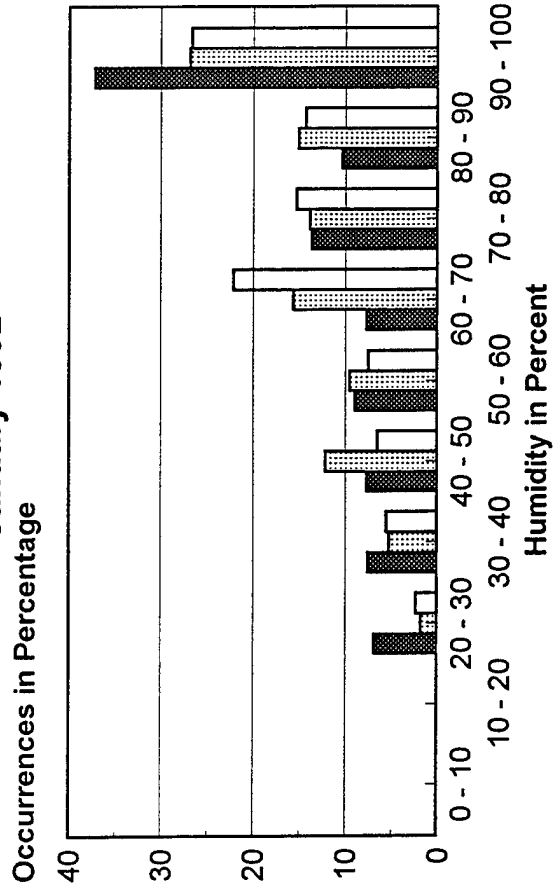
December 1991



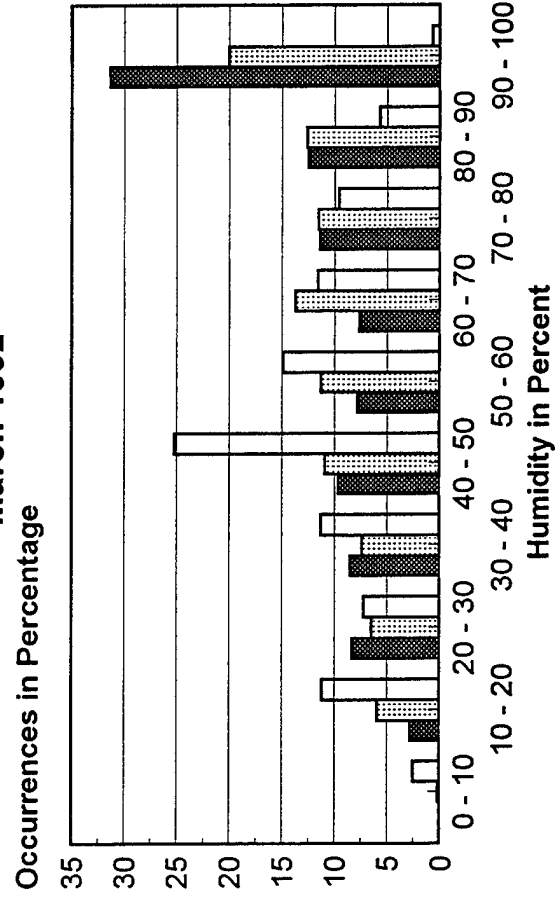
February 1992



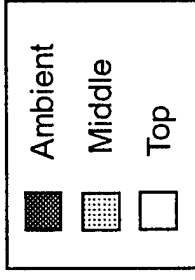
January 1992



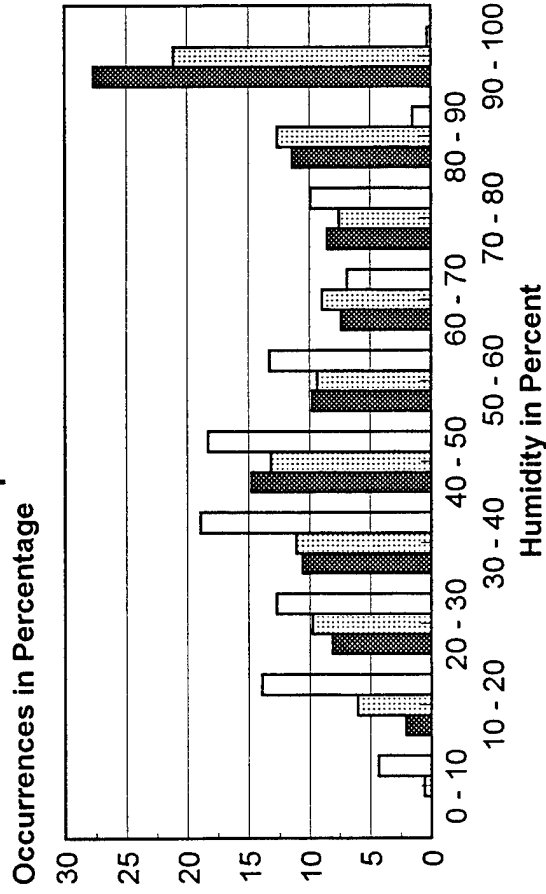
March 1992



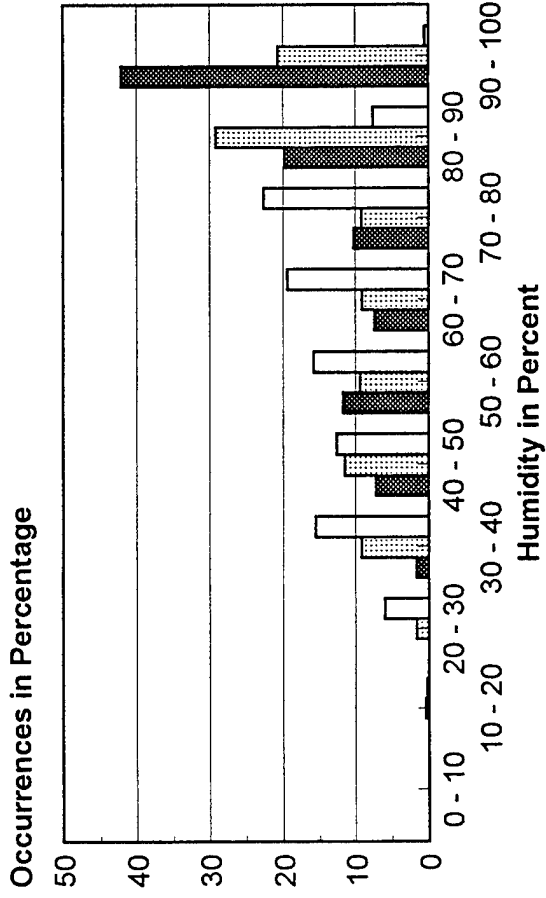
Humidity Histogram for Pallet #9



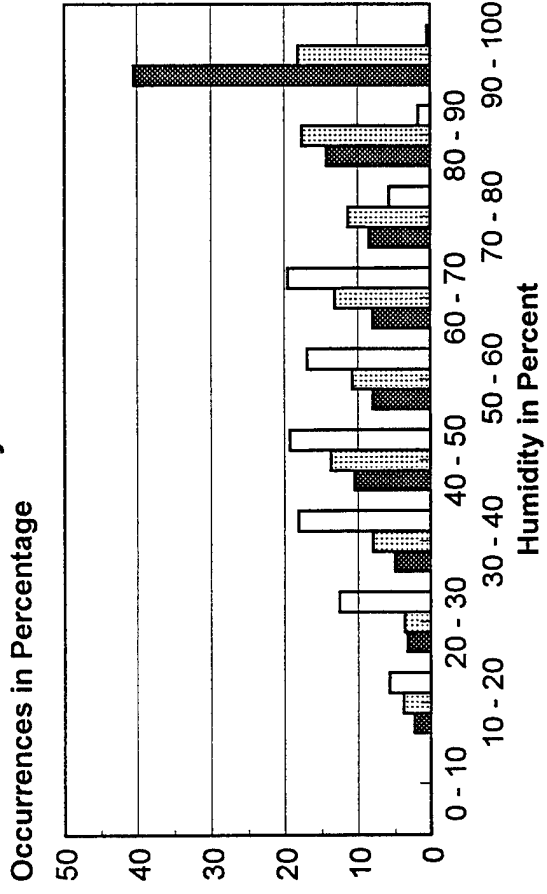
April 1992



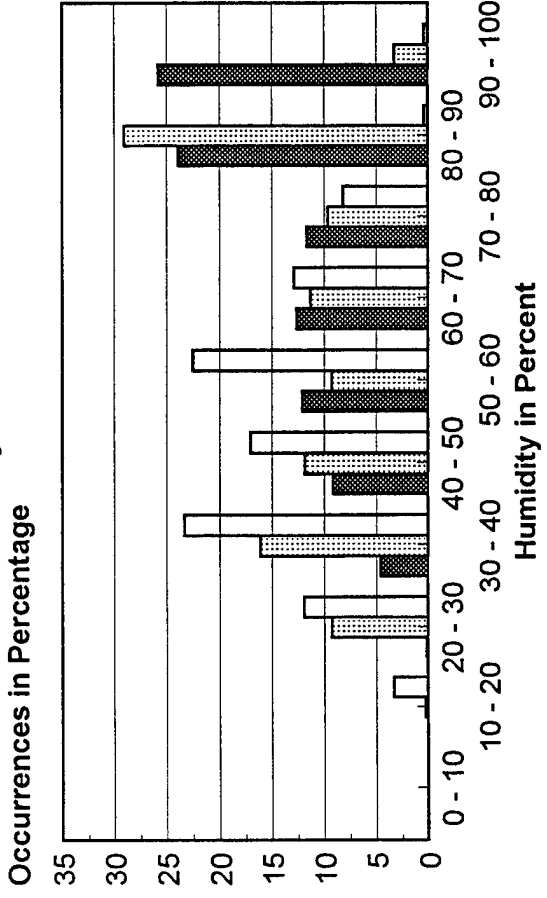
June 1992



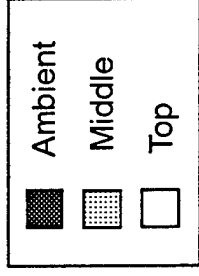
May 1992



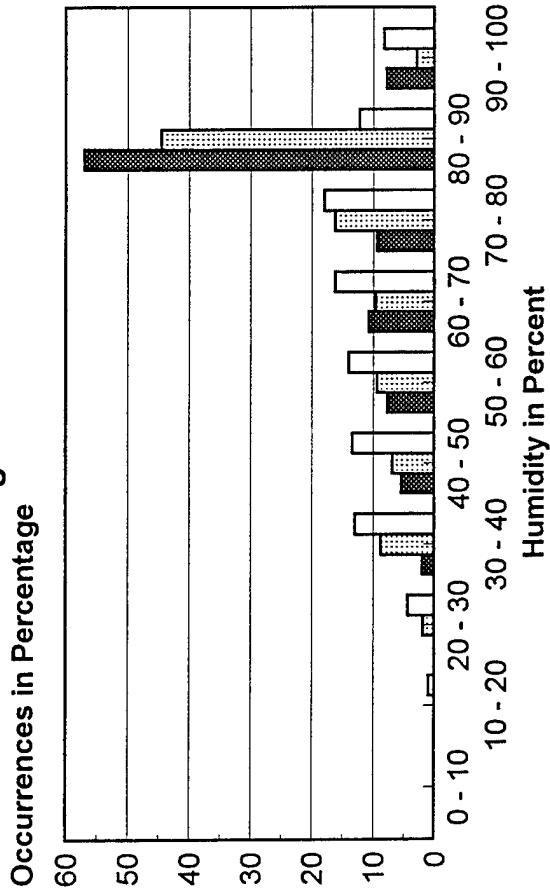
July 1992



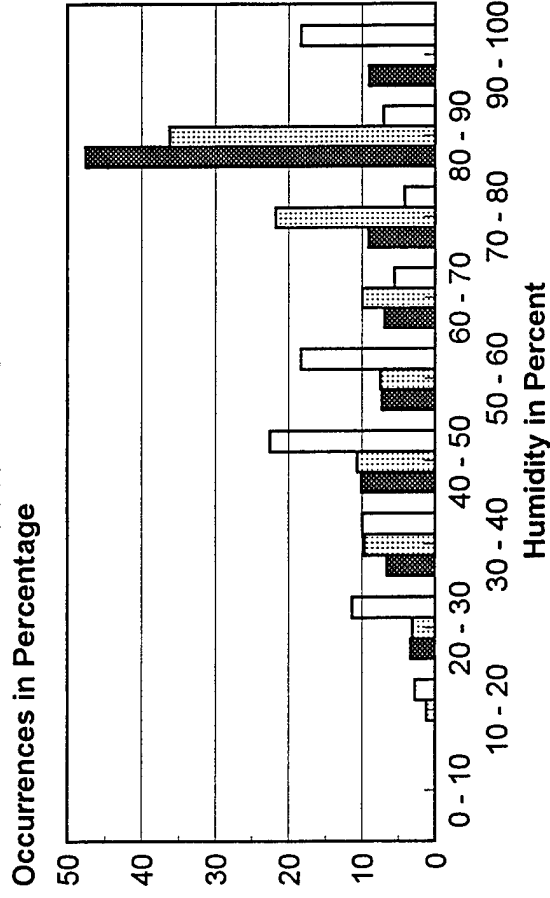
Humidity Histogram for Pallet #9



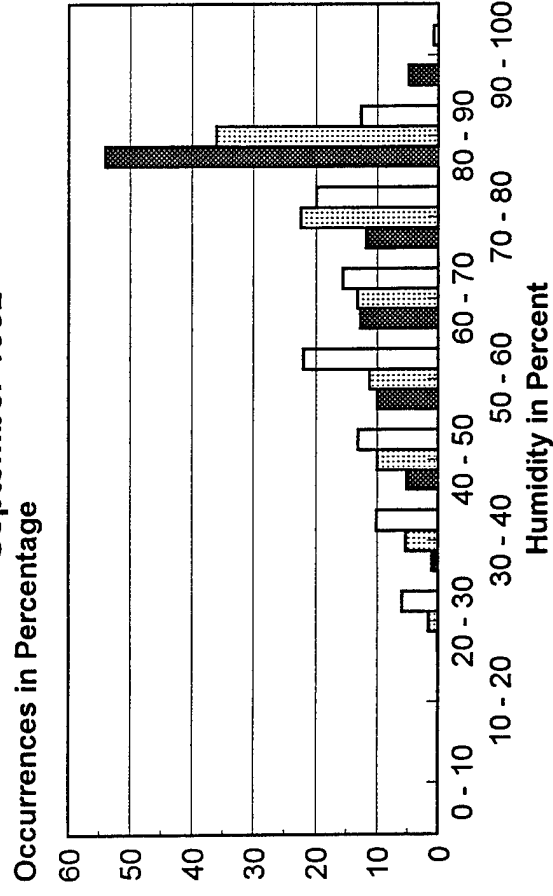
August 1992



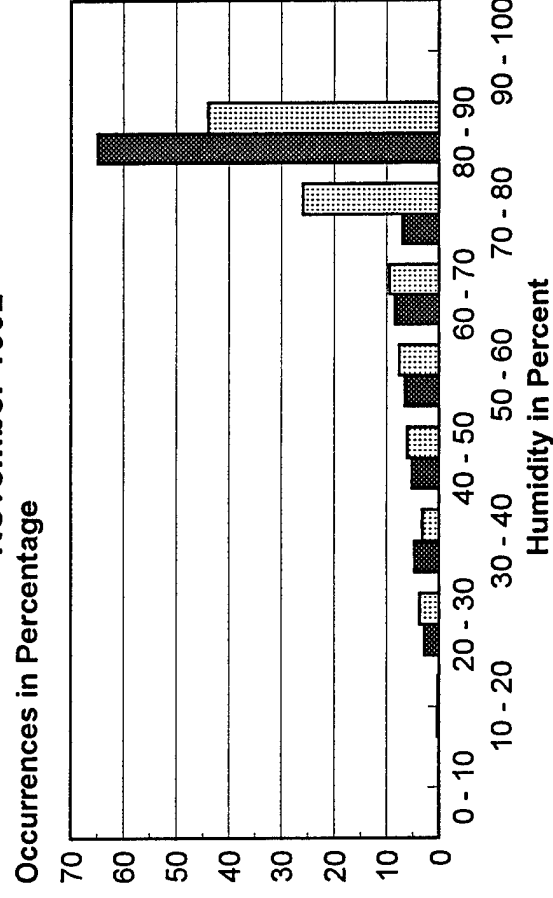
October 1992



September 1992

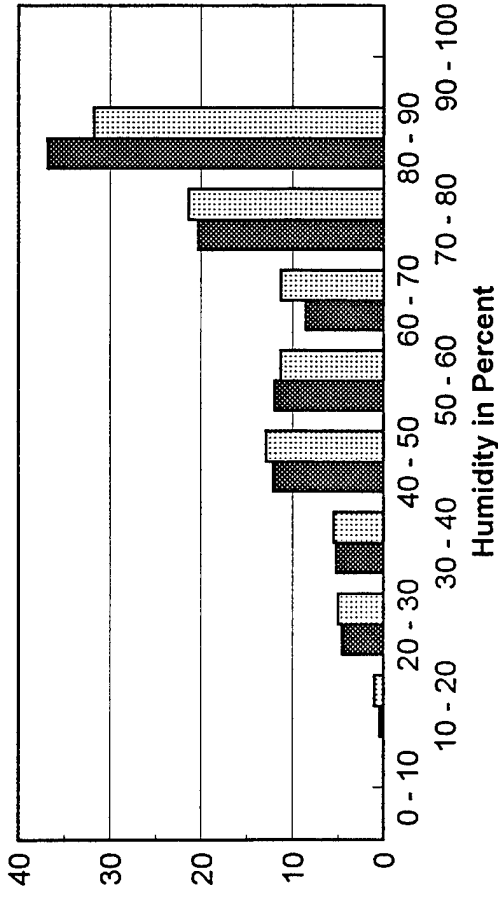


November 1992

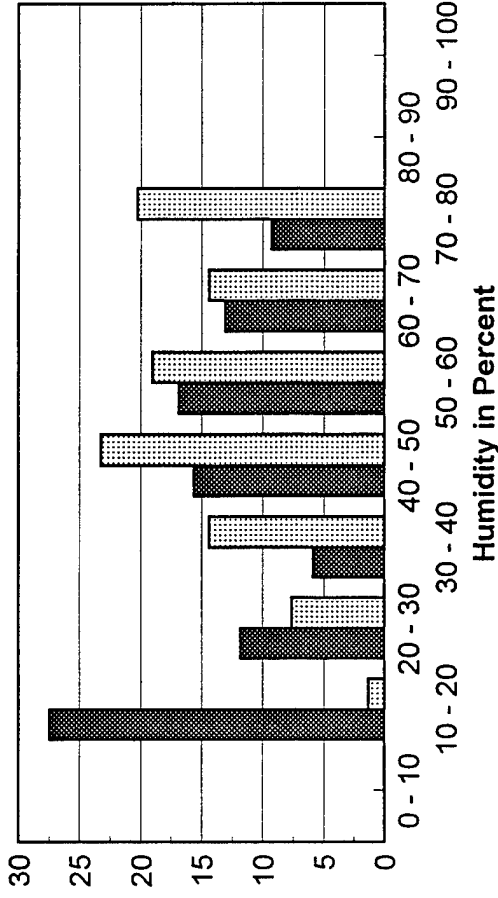


Humidity Histogram for Pallet #9

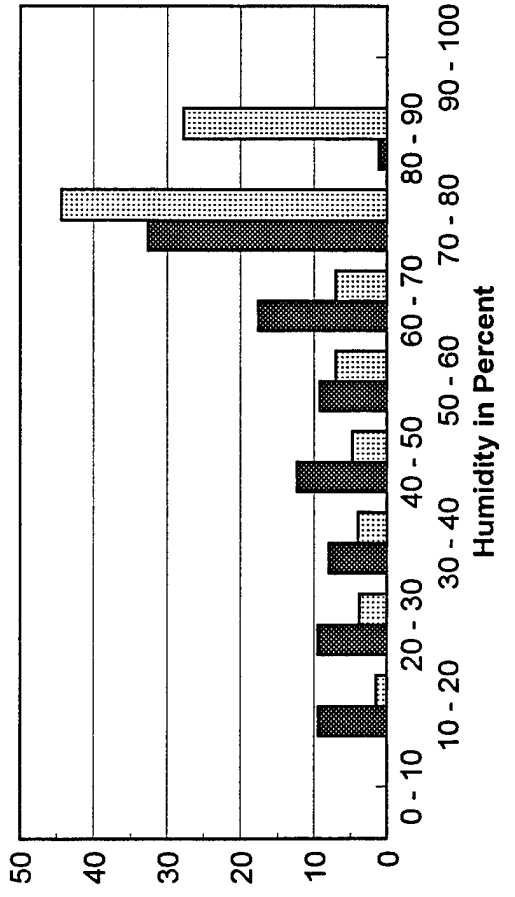
December 1992



February 1993



January 1993



Ambient
Middle
Top